THE SIDEREAL MESSENGER.

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

APRIL, 1888.

Thou Lord in the beginning hast laid the foundation of the earth and the heavens are the works of thy hands.

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DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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ON THE ADJUSTMENT OF A SEXTANT.

PROFESSOR GEORGE C. COMSTOCK.*

For the MESSENGER.

My attention has recently been called to the needlessly crude character of the methods commonly given for the adjustment of a sextant. As an example of these I may cite the method of adjusting the index glass given by *Chauvenet's Spherical and Practical Astronomy*, Vol. II., Articles 82 and 102. "Set the index near the middle of the arc; then placing the eye very nearly in the plane of the sextant and near the index glass, observe whether the arc seen directly and its reflected image in the glass appear to form one continuous arc, which will be the case only when the glass is perpendicular." * * * "By the method of adjusting the index glass given in Art. 82 it may easily be placed within 5′ of its true position."

To test the truth of this assertion I detached from its mounting the index glass of an excellent sextant belonging to the Washburn Observatory and secured it in place in such a manner that by turning a coarse micrometer screw the inclination of the mirror to the plane of the sextant could be altered at will, one revolution of the screw changing the inclination by 74′. Numerous experiments with this apparatus showed that by following the method above given the probable error of a single setting of the index glass made by turning the micrometer screw was about ±4′. This can not, however, be taken as a measure of the accuracy of the above method of testing the adjustment, since the to and fro motion imparted to the mirror by means of the micrometer screw very materially assists in determining the position in which the direct and reflected portions of the limb seem to form a continuous arc. Having determined from the mean of forty settings of the mirror, the micrometer reading at which the

* Director of Washburn Observatory, Madison, Wis.

mirror was perpendicular to the plane of the sextant, I found from experiment that if the micrometer were set anywhere within a quarter of a revolution of this reading, the eye could not detect any error in the position of the mirror, but that it could readily detect it when the micrometer was set half a revolution wrong. When the micrometer was set from fifteen to eighteen divisions wrong (1 div. = 1′.6) the eye was not satisfied with the appearance of the two parts of the arc, but was unable to determine which way the mirror ought to be moved to correct the error.

I think we may conclude from these experiments that the method of making this adjustment given by *Chauvenet* and most other writers upon the theory of the sextant, may easily be in error by as much as 20′. For many purposes for which a sextant is used an error of this magnitude in the adjustment is quite insignificant, but if the greatest precision attainable is desired the adjustment must be more carefully made. The following method is unexceptionable as regards accuracy and when all the adjustments of the instrument are to be tested is perhaps as convenient as any other.

Let the sextant be placed upon a table, or other firm and level support and let an auxiliary mirror be placed approximately perpendicular to the sextant telescope at a distance of from ten to twenty feet from it. The first step in the adjustment is to make this mirror perpendicular to the plane of the sextant. Prepare two sights by fastening threads across circular apertures in pieces of card board as in the accompanying diagram. These pieces of card board must be so fastened to wooden or metalic bases that when placed in an upright position on the arc of the sextant the centers of the apertures shall be as nearly as possible on a level with the top of the silvered part of the horizon glass. Place these sights on the sextant arc as far apart as possible and in such a position that by sighting through the apertures the image of the one nearest the auxiliary mirror may be seen reflected from it.

Then holding the eye in the line determined by the cross threads let an assistant turn the mirror until the image of the aperture in the front sight is bisected by the horizontal thread. This operation as well as all the following ones, will be facilitated by throwing a beam of reflected sunlight upon the sextant. I interchange the sights and repeat the operation in order to eliminate any want of parallelism between the line of sight and the plane of the sextant. The mean of the two positions of the mirror thus found will be perpendicular to the plane of the sextant, and if the operations have been carefully performd the error of its position ought not to exceed 1′ or 2′ as I have found by repeated experiment.

The adjustments of the sextant can now be very easily made by the use of this mirror.

I. To adjust the index glass: Tie a white thread around the middle of the index glass and turn the glass until it is parallel to the mirror which has just been adjusted. If the index glass is perpendicular to the plane of the sextant a ray of light proceeding from the thread to the mirror will be reflected back to the index glass and then to the mirror again, etc., producing a series of images of the thread, and if the eye be held in the plane passing through the real thread and its first image all succeeding images should be hidden behind the first one. If not so hidden they will form a series upon one side of it and the index glass must be adjusted until the images coincide. It is evident that this is a very delicate test and the accuracy of the adjustment is limited only by the accuracy with which the auxiliary mirror can be placed perpendicular to the plane of the sextant.

II. To adjust the horizon glass: This is best done by bringing into coincidence the images of a distant object seen directly and by reflection from the sextant mirrors. For an approximate adjustment the image of one of the sights seen in the auxiliary mirror may be used.

III. To adjust the line of sight of the telescope: Bring into the field of view the reflected image of one of the sights placed upon the arc of the sextant and by turning the adjusting screws which secure the telescope collar in place, bring the image of the aperture in the sight midway between the cross threads of the telescope. In making this adjustment it will be well to use the highest power eye-piece and the threads

in the field of the telescope must, of course, be placed approximately parallel to the plane of the sextant.

The angle which the line of sight of the telescope makes with a perpendicular to the horizon glass, called β by most writers, is one of the constants which enter into the theory of the sextant. Its value may be found to a sufficient degree of approximation in connection with these adjustments. Place one of the sights on top or in front of the horizon glass and turn the whole sextant about until the image of this sight reflected from the mirror is seen midway between the cross threads of the telescope, which must now be placed perpendicular to the plane of the sextant. Set the index glass approximately parallel to the auxiliary mirror and place against the front of the glass a piece of paper folded so as to present a sharply defined vertical edge. A series of images of this paper will be formed in the mirror. Let the eye be placed in the plane passing through the edge of the paper and its first image and turn the index glass until the other images in the mirror are just hidden behind the first. The reading of the vernier corrected for index error equals 2β as may be seen by constructing a figure representing the position of the index and horizon glasses, the auxiliary mirror and the line of sight of the telescope corresponding to the observation, and the position of the index glass when parallel to the horizon glass.

ON THE NEBULAR HYPOTHESIS OF LA PLACE.

GEORGE W. COAKLEY.*

The bases of La Place's theory of the formation of the solar system are to be found in certain propositions which he has rigorously demonstrated in his "Mechanique Celeste," together with certain numerous relations among the elements of this system, which are the results of observation.

Almost the whole of the second volume of the "Mechanique Celeste," consisting, in Bowditch's translation, of 990 large quarto pages, is taken up with the mathematical investigations of the attractions of bodies of various forms, at rest or

* Professor of Mathematics and Astronomy in the University of the City of New York.

rotating on their axes. The attractions of all their parts for each other, or for any external or internal particle, are considered. The form of equilibrium of the surfaces of the earth and other planets, and of the sun, is the subject of minute and extensive investigation.

La Place's theory of the tides, both in the waters that cover the earth and its atmosphere, form a part of this same investigation. In the course of these investigations La Place establishes the *great principle* of the *constancy of areas*, described by the radii drawn to all parts of a revolving body, whether that body be solid, liquid or gaseous; or any combination of these three states of matter.

This principle may be stated as follows:

Suppose any body to revolve around an axis, passing through its centre of gravity; and suppose a plane to be drawn through the centre of gravity perpendicular to this axis. Call this plane the equator of the rotating body; then, if radii be drawn from the centre of gravity to every particle of the rotating mass, and if these radii and particles be considered to be projected perpendicularly upon the plane of the equator, the rotation of the body will carry each of these projected radii over a certain area in a given time. But as long as the mass of the rotating body remains the same, provided it is subject to the action of no external force, then, however the form of the body may change, the *sum of the products of all the particles by the projected areas which they describe in that given time*, will remain *constantly the same*. If also there be any external forces acting on the body, but directed always towards the centre of gravity, the constancy of these areas will still be maintained. This constancy, however, will not be maintained if the external variable forces be directed towards *several different centres*; nor will the sum of the areas be the same if the *mass* of the rotating body be *increased* or *diminished*.

If no change takes place in the form or size of the rotating mass, especially in the absence of external forces, then the body will have a constant, uniform motion about its axis. There are cases, moreover, where the axis is continually changing within the mass, and other cases where the axis is fixed and unchangeable within the mass. This last, or stable axis of rotation, occurs especially when the body rotates around the *shortest axis* that can be drawn through it.

These principles are rigorously demonstrated in the "Mechanique Celeste" and in other works.

For a statement of the Principle of Constant Areas in a mathematical form, and some deductions from it, see the concluding part of this article in subsequent number.

If a body have no rotation, supposing its parts to be of a yielding nature, like those of a liquid or a gas, or even a semi-liquid; then, in obedience to the mutual attraction of its particles, the body must take on a perfectly spherical form. For it is evident that the resultant of the attractions of all its parts will produce a pressure towards the centre of gravity, which pressure from opposite sides towards that centre will be in proportion to the depth, or to the distance from the centre. Hence one portion of the body's surface cannot be further from the centre than its diametrically opposite portion. If they were at different distances, the opposite pressures would be unequal, and the gaseous, liquid, or semi-liquid mass would yield in the direction from the greater pressure, or greater elevation, towards the side where the elevation and constant pressure were less. Moreover, as such masses transmit pressure equally in all directions, it is evident that the bounding surface of the body can be no other than that of a sphere.

If, however, such a body have at first a very slow rotation around an axis, a new force will arise from this rotation, tending to change the form of its bounding surface. La Place, and the older writers on mechanics, called this new force the *centrifugal force*. I shall apply to it the same name.

The force arises, as is well known, from that property of the inertia of matter, which makes it, if in motion, constantly strive to continue that motion in a straight line. When, therefore, any particle of a rotating mass is carried in a circle about the axis of rotation, it strives by its inertia to leave the circumference of that circle, and fly off in a tangent, endeavoring thereby to increase its distance from the axis. This is the centrifugal force which counteracts a part of the gravitation and pressure towards the centre, and thus changes the form of the body's bounding surface from that of a sphere to that of a spheroid or ellipsoid, whose axes are more or less disproportionate according to the amount of the centrifugal force, or according to the velocity

of rotation on the axis. On the other hand, when such a rotating mass has a given ellipsoidal figure of equilibrium, in accordance with a given velocity of rotation, and consequent centrifugal forces, should it by any means be made to rotate more slowly, or should the centrifugal forces be diminished by any causes, then the tendency of the pressures towards the centre will begin to renew their sway, and to impress upon the rotating mass a form approaching more nearly that of a sphere.

To appreciate the strength of La Place's theory, it will be necessary to look more closely into the subject of centrifugal force. It is demonstrated by all writers on mechanics, including La Place, that, in a rotating mass, the value of the centrifugal force exerted on a unit of the mass situated at the distance r from the axis, may be measured by the square of the velocity at that distance, divided by the radius. If, therefore, the angular velocity of rotation be denoted by ω, the velocity at the distance r from the axis will be $r.\omega$. Hence the centrifugal force, f, at the distance r from the axis, exerted on the unit of mass at that distance is

$$f = \frac{(r.\omega)^2}{r} = \frac{r^2\omega^2}{r} = r.\omega^2.$$

Hence, as long as the angular velocity of rotation remains the same, the centrifugal force exerted on each unit of the body's mass will be proportional to the distance of that unit from the axis of rotation. If, therefore we consider especially the different units of mass at or near the surface of the rotating body, it is evident that their centrifugal forces will increase as they are nearer the equator of that body, and that those forces will diminish for the parts more remote from the equator, because the distances from the axis increase toward the equator, and diminish as the parts recede from the equator. Moreover just at the equator the centrifugal force is directly opposed to the gravitation and pressure towards the centre, while the direction of the centrifugal force is more and more oblique to that of gravity, and therefore less effective in opposing it, as the parts of the surface are more removed from the equator of the rotating body. This is easily shown by a very simple mathematical investigation, upon which, however, it is hardly necessary to enter in this paper.

The most interesting case of a rotating body, the one in fact which undoubtedly led La Place to form his celebrated hypothesis, is the one which he investigates in the second volume of the "Mechanique Celeste," Book III., Chapter vii. The chapter is entitled "On the Figure of the Atmosphere of the Heavenly Bodies."

He supposes a body like the earth, or Jupiter, or the sun, to have a more or less dense nucleus, surrounded by a rare, elastic atmosphere of any extent possible. The nucleus he considers either solid, or so dense compared with the atmosphere as to be relatively solid, and to contain by far the greatest amount of the body's mass. The form of the nucleus, for convenience, he takes to be already reduced to that of a spheroid differing but slightly from that of a sphere, but the form of the atmosphere's bounding surface he leaves to be determined solely by the play of the centrifugal and gravitating forces resulting from any given mass and velocity of rotation that the body can have. This investigation is begun upon the 519th page of the second volume, or a little after the middle of the volume of nearly 1,000 pages. But to follow the demonstration completely presupposes a familiarity with not only about all of the previous 500 pages, but also with most of the first volume as well. It is rather too much mathematics to compress within the limits of this paper.

Nevertheless the equation of equilibrium which La Place demonstrates for the surface of the atmosphere of such a rotating body is simple enough; and the subsequent use he makes of it is so important to the right appreciation of his celebrated hypothesis, that I must ask you to allow me to state and explain, but not to prove it.

In Bowditch's translation it is the equation marked number [2120]; and is as follows:

$$c = \frac{2}{r} + \frac{n^2}{M} \cdot r^2 \sin^2 \theta.$$

I have, however, replaced La Place's a, in this equation by its value $\frac{n^2}{M}$, deduced in Bowditch's note.

The meaning of the equation is this; La Place has previously proved that the figure of equilibrium of the atmosphere

is an ellipsoid of revolution with its shortest axis coinciding with the axis of rotation. Suppose, then, a section of this surface to be made by a plane passing through the axis of rotation. The section will be a curve, an ellipse, of which the above is the equation. c is a constant introduced by integration, the value of which is yet to be determined. r is the variable radius drawn from the centre of gravity, or from the ellipse, to any point of the section on the surface of the atmosphere. θ is the variable angle which this radius makes with the axis of rotation. M is the mass of the rotating body, including the atmosphere. n is the angular velocity of rotation, the same which has previously been denoted by ω.

To determine the constant, c, La Place supposes the radius, r, to be drawn to the point where the axis of rotation meets the surface of the atmosphere, and denotes the length of this radius by R. This, of course, is the polar radius of the elliptical section of the atmosphere. This radius, R, makes with the axis of rotation the angle $\theta = o$. Making these substitutions in La Place's equation, the value of his constant, is obtained, namely

$$c=\frac{2}{R}$$

Replacing c by this value, his equation becomes

$$\frac{2}{R}=\frac{2}{r}+\frac{n^2}{M}.r^2 sin^2\,\theta. \quad [2123] \text{ of Bowditch.}$$

If now we suppose $\theta=90°$, r will become the *equatorial radius*, for which La Place puts R'. Hence, as $sin.\ \theta=1$, the equation [2122] becomes

$$\frac{2}{R}=\frac{2}{R'}+\frac{n^2}{M}.R'^2.$$

Hence,

$$\frac{n^2}{M}.R'^2=\frac{2}{R}-\frac{2}{R'}=\frac{2(R'-R)}{RR'}, \text{ or } \frac{n^2}{M}.R'^3=2\left(\frac{R-R}{R}\right).$$

which is the form in which La Place puts his next equation.

(TO BE CONTINUED.)

ASTRONOMICAL PHOTOGRAPHY.*

The application of photography to astronomical research is rapidly transforming its destinies. The more closely the exquisite sky prints recently taken at Paris and elsewhere are studied, the more opulent of promise they appear. Their pictorial beauty is the least of their merits. In the eyes of the astronomer their eminent value lies in their capability of exact measurement. Upon this basis of fact rest anticipations which to unaccustomed ears sound exaggerated, but which the future will, unless we are much mistaken, amply justify. We can have no hesitation in admitting that what has been done, not by chance, but on system, can be done again. Results already obtained can be repeated and multiplied. It needs no more—although much more will probably be accomplished—to ensure a new birth of knowledge regarding the structure of the universe.

The scientific importance of Daguerre's invention was perceived from the outset. In formally announcing it to the Academy of Sciences, August 19, 1839, Arago characterized it as a "new instrument for the study of nature," the manifold uses of which must baffle, and would assuredly surpass, prediction. "En ce genre," he added significantly, "c'est 'sur l'imprévu qu'on doit particulièrement compter."† And it is indeed the unforeseen which has come to pass. Arago himself, with all his readiness to admit incalculable possibilities, would have been staggered by a forecast of the work now actually being done.

Celestial photography, as was natural, made its first essay with the moon. The broad, mild face of our satellite, diversified with graduated lights and intense shadows, formed a

* From January "Edinburgh Review," being a review of the following articles:

1. La Photographie Astronomique a l'Observatoire de Paris et la Carte du Ciel. Par M. le Contre-Amiral E. Mouchez. Paris: 1887.

2. An Investigation in Stellar Photography conducted at the Harvard College Observatory. By Edward C. Pickering. Cambridge, U. S.: 1886.

3. First Annual Report of the Photographic Study of Stellar Spectra conducted at the Harvard College Observatory. By Edward C. Pickering, Director. Cambridge, U. S.: 1887.

4. The Applications of Photography in Astronomy. Lecture delivered at the Royal Institution, Friday, June 3, 1887. By David Gill, LL.D., F.R.S. (The Observatory, July and August, 1887.)

5. Die Photographie im Dienste der Astronomie. Von O. Struve. (Bulletin de l'Academie Imperiale des Sciences de St. Petersbourg, Tome xxx. No. 4: 1886.)

† Comptes Rendus, tome ix. p. 264.

tempting subject for the nascent art. At Arago's suggestion, accordingly, Daguerre exposed one of his sensitive plates to the lunar rays, but with a disappointing result. Nothing worthy the name of a picture made its appearance. Professor J. W. Draper, of New York, however, obtained early in 1840 some little prints, not altogether characterless of the lunar surface, after which the subject dropped out of sight during ten years. It was resumed at Harvard College Observatory by George P. Bond, one of whose lunar daguerreotypes attracted deserved attention at the Great Exhibition of 1851. The light employed to produce them was concentrated by a telescope fifteen inches in aperture, equatorially mounted, and kept fixed by a clock-work movement upon the moving object to be depicted.

Bond's pictures marked the close of the first or tentative period in celestial photography. In 1851, the collodion process was introduced by Frederick Scott Archer, and rapidly superseded all others. Daguerreotypes, lunar, solar and terrestrial, began to assume an antiquarian interest and aspect.

Collodion is a colorless, semi-viscous fluid produced by dissolving gun-cotton in a mixture of alcohol and ether. Spread upon glass, it forms a transparent membrane rendered susceptible to the action of light by impregnation with salts of silver. The 'sensitiveness' of these substances is due to their possessing a molecular equilibrium so delicate as to be overturned by the quick ethereal impacts of the vibrations of violet light. The metal they contain, thus partially released from the bonds of chemical combination, is ready to attract further deposits; and the opportunity of exercising this power of appropriation is afforded by the processes of development.* A photograph is hence a picture painted in metallic silver under the regulating influence of light.

Mr. Warren De la Rue was the first to turn Archer's improvement to account for astronomical purposes. He began his photographic work towards the close of 1852 with a thirteen-inch reflector of his own construction which gave him successful pictures of the moon, one inch across, in ten to thirty seconds. Some taken later with improved means bore enlargement to eight inches, and clearly showed details

* Some kinds of development merely complete the "reducing" process begun by the action of light, without adding any fresh metallic supplies.

representing an actual area on the moon's surface of about two and a half square miles. The distribution of light and shade in them differed so notably from that perceived with the eye as to afford hints (it was thought) towards a science of lunar geology, formations of different epochs being distinguished by their varying powers of reflecting the actinic rays.* The marked deficiency in chemical power of the so-called "seas," in especial, suggested that they might in reality be plains clothed with vegetation, the vital needs of which were supplied by a dense, low-lying atmosphere.

Mr. De la Rue showed further that, by the stereoscopic combination of two photographs taken at opposite phases of the moon's libration, something might be learned as to the relative age of lunar craters. The deep furrows diverging from Tycho, for instance, were perceived to run right through some craters, but to be overlaid by others.† Obviously, then, the dislocated craters were already in existence when these clefts opened, while the unaffected ones were of later production. With the improved photographic methods now in use, it is quite possible that the real position in Jupiter's atmospere of the great red spot adhering to his southern belt may in this way be determined; perhaps even indications derived as to the nature of the mysterious Martian canals.‡

The immediate followers of De La Rue in lunar photography were two gifted Americans, Dr. Henry Draper and Lewis M. Rutherford of New York. The moon, as seen with the naked eye, is about one tenth of an inch in diameter, that is to say, it is just covered by a disc of that size held at the ordinary distance for clear vision.§ One of Draper's pictures, taken with a fifteen-inch silvered glass reflector, Sept. 3, 1863, and subsequently enlarged, showed it as three feet across, or on a scale of about sixty miles to the inch. The spectator was virtually transported to a point 600 miles from the lunar surface.

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* Report British Association, 1859, p. 145.

† Monthly Notices, vol. xxiii. p. 111.

‡ The rotation of the planets gives the differences in the point of view requisite for obtaining stereoscopic relief. Photographs taken at intervals—for Jupiter of twenty-six, for Mars of sixty-nine minutes—combine with the proper effect. De la Rue, "Report Brit. Ass." 1859, p. 148.

§ H. Draper, "Quart. Jour. of Science," vol. i. p. 381.

Reflectors possess the great advantage of being perfectly achromatic. Undulations of all wave lengths are collected by them at a single focus. In refractors, on the other hand, there is always a certain amount of dispersion. Opticians have to choose which rays to unite, leaving the others to shift for themselves. They in general, of course, bestow exclusive attention on those of greatest visual intensity. Ordinary achromatics have hence no sharp chemical focus. Rutherford, however, took the more rapid vibrations alone into account in calculating the curves of an object glass of eleven inches designed expressly for photographic use. He thus set the example of deliberately constructing a telescope totally unserviceable to the eye. By its means were obtained in 1865 lunar photographs which marked the culmination of the art in its second or "wet-collodion" stage.

Yet the result, striking as it was in some respects, somewhat disappointed expectation in others. The details of structure were not so distinctly given as to serve for a criterion of future change; nor has any lunar photograph yet taken shown the crispness of the best telescopic views. The reason is obvious. Atmospheric shiverings which the eye can to some extent eliminate, produce their full effect on the sensitive plate. The resulting picture is the summation of a multitude of partial impressions due to evanescent distortions and displacements of the image.

It was perhaps owing to a sense of partial failure that lunar photography fell into neglect during twenty years. Now, at last, there are signs of revived interest in it. Recent improvements afford great advantages for its cultivation. Owing to the high sensitiveness of modern plates the images thrown upon them can be strongly magnified, while the time of exposure is still kept extremely short. The MM. Henry have accordingly adopted the plan of photographing the moon in sections, six or eight of which cover the visible hemisphere and are united to form a map one and a half to two feet in diameter. A repetition of the process at intervals will test the occurrence of variations in lunar topography extending over not less than one and one half square miles.

The finest telescope in the world for the purposes of moon-portraiture is undoubtedly the giant refractor of the Lick

Observatory in California. With an aperture of three, and a focal length of fifty feet, it gives a direct image of the moon six inches in diameter, negative impressions of which may be enlarged with advantage to perhaps twelve feet. But the third lens, by which the correction of this superb instrument can be modified at pleasure to suit the actinic rays, has yet to be provided; and perfect glass discs of thirty-six inches are not to be had for the asking. They may be bespoke a long time before they are forthcoming.

The sun can now be photographed in the inconceivably short space of the one hundred thousandth part of a second!* A short exposure, followed by a long and strong development, gives the best results; and it is difficult to see how those obtained by M. Janssen at Meudon during the last eight or nine years can be much improved upon. It might, however, be found possible to work on a larger scale. Advantage for the exhibition of details would probably be derived from the use of a solar image more highly magnified than has hitherto been customary.

The historical starting point of solar photography is a daguerreotype taken at Paris by MM. Foucault and Fizeau, April 2, 1845. The attempt, though not unsuccessful, remained isolated for a number of years. The eclipsed sun was the subject of the next experiment. Busch and Berkowski of Königsberg obtained a slight but distinct impression of the corona during the total eclipse of July 28, 1851. But the triumph of practically establishing the value of photography as a means of investigating the solar appendages was reserved for Mr. De la Rue and Father Secchi. By the comparison of photographs taken at various stages of the eclipse of July 18, 1860, the status of the "red protuberances" was settled forever. The advance of the moon *over* them proved beyond cavil that they belong to the sun.

The camera is an encroaching instrument. So surely as it gains a foothold in any field of research, so surely it advances to occupy the whole, either as adjunct or principal. Telescopic and direct spectroscopic observations during solar eclipses are now altogether subordinate in importance to photographic records of them. Fleeting appearances likely either to escape or to mislead the eye during the lapse of

* Janssen "Annuaire du Bureau des Longitudes," 1883, p. 809.

those counted and crowded moments, are stored up for leisurely interpretation; and the whole working power of the mind can thus be devoted to the collection of materials for subsequent discussion. The discovery of a comet close to the sun, May 17, 1882, is a picturesque incident of eclipse photography. "Tewfik," as the object was named in compliment to the reigning Khedive, made its first known appearance to terrestrial spectators during the seventy-four seconds of total obscurity at Sohag. It was caught with beautiful distinctness on Dr. Schuster's plates of the corona, and its place was measured from them; but for lack of previous or subsequent observations, it must forever remain unidentified.

But we must hurry on, lest time fail us to describe the latest developments of this marvelous art. They are due to improvements of a fundamental kind in photographic processes. Collodion-plates can practically only be used in a wet state. This narrowly limits the time of exposure. Moreover, the preparation of each plate must immediately precede and its development immediately follow exposure—conditions which inconveniently hamper the operations of the astronomical photographer. In 1871, however, gelatine was by Dr. R. L. Maddox substituted for collodion, silver bromide being exclusively used as the sensitive substance. The advantages of the new process were quickly perceived and improved. Gelatine is not, like collodion, a merely neutral vehicle. It possesses a reducing power of its own which steps in as an auxiliary to that of light. Hence the extraordinary rapidity of the "gelatino-bromide" plates now universally employed. Chief among their recommendations to "astrographers" are the faculties of keeping indefinitely, and gaining five fold sensitiveness by drying. They can thus be prepared at leisure, exposed with constantly accumulating effect for an unlimited period, and developed when convenient.

Their singular adaptation to the exigencies of celestial research was first perceived by Dr. Huggins, who used "dry plates" in his experiments on photographing stellar spectra in 1876; and his advice and example were followed, a few years later, by Draper and Gould in America, by Common and Janssen in Europe. The change has proved of the highest moment to science.

We have heard much lately of the power and promise of the "new astronomy," and celestial physics have indeed, in our day, entered upon a splendid career. Like "England's great Chancellor," it "has taken all knowledge to be its province." No truth regarding the material universe is indifferent to it. It assimilates every variety of information. Scarcely an experiment can be performed in a laboratory without directly or indirectly promoting its interests. The labors of electricians, meteorologists, geologists, mineralogists, chemists, are all made available. No science can be its rival, because each one is its colleague and ally. The results have been commensurate with this vast extension of resources. Knowledge, ample and assured, has been accumulated of a kind which, previous to the middle of the present century, appeared to the profoundest thinkers for ever unattainable. Undreamt-of analogies between celestial and terrestrial phenomena have been disclosed. Above all, boundless prospects of future discovery have been thrown open, and the keenest stimulus to persistent effort has thus been supplied.

The new astronomy has accordingly found eager and numerous votaries in all its various branches. Yet its popularity seemed attended by a twofold danger. The majestic elder astronomy—the astronomy of Hipparchus, Bradley, and Bessel, of Newton, Leverrier, and Adams—might, it was to be feared, suffer neglect through the predominant attractions of its younger, more versatile, and brilliant competitor; or its lofty standard of perfection might become lowered through the influence of workers more zealous than precise, recruited from every imaginable quarter, inventive, enthusiastic, indefatigable, but unused to the rigid requirements of mathematical accuracy.

Both these perils have been happily averted. The prospect has suddenly cleared and brightened. The new astronomy has submitted to bear the yoke of the old. The old astronomy has adopted the new methods, and is even now anxiously fitting them to its own sublime purposes. It has enlarged its boundaries without departing one iota from its principles. By an effort which shows it to be still young and elastic, it has seized the key of the situation, and now stands hopeful and dominant before the world.

This union of the two astronomies has long been in remote preparation. Artists and experimenters innumerable have unconsciously urged it on. It has been promoted by improvements in the manufacture of glass, in the shaping of lenses, in the grinding, polishing, and silvering of mirrors, by the growth of intimacy with the peculiarities of salts of silver, and by the growth of skill in their employment for the purposes of light portraiture. The meeting last year at Paris of an International "Astrophotographic" Congress marked its accomplishment. This event will undoubtedly prove to be of the "epoch-making" description. Future ages will look back to it as the beginning of great achievements. To have been concerned with it will in itself be counted as giving a title to fame. Circumstances concurred to bring it about just at the right moment.

Stellar photography originated with a daguerreotype of Vega (α Lyræ) taken at Harvard College July 17, 1850. The oval shape of an image of Castor obtained about the same time indicated its duplicity; but these impressions were very faint, and none at all could be derived from objects of inferior lustre, such as the pole-star. Then the collodion process was introduced, and with its aid the younger Bond, in 1857, extended the depicting powers of the camera to stars of the sixth magnitude. Still more significantly, he demonstrated the applicability of photography to the astronomy of double stars by executing upon prints of *Mizar* in the Tail of the Great Bear a set of measures which proved superior in accuracy to those of the ordinary visual kind. He also led the way in photographing what are called "star-trails." When Vega, the clock being stopped, was allowed to "run" upon the plate by its own diurnal motion, its passage remained marked by a fine line. The principle of "trails" has been turned variously to account in recent investigations.

Rutherford reached the limit, in this direction, of what was possible to be done with wet plates. In and after the year 1864 he secured photographs of a number of clusters, including stars down to the ninth magnitude, from one of which Dr. Gould deduced places for nearly fifty Pleiades, agreeing so closely with Bessel's, of a quarter of a century earlier, as to put beyond doubt the extreme minuteness of

the relative motions of those stars. When it is added that quantities of $\frac{1}{500000}$ of an inch were measurable on Rutherford's negatives, it becomes clear that the era of observations "of precision" by photographic means was fast approaching.

With the introduction of dry plates it may be said to have arrived. They were indeed indispensible, no less for charting than for exploring the skies. Photography is of service for these purposes just in proportion to the number of faint stars it can register. But here length of exposure is all-important; and long exposures are impossible with plates subject to change by evaporation.

Impressions on the sensitive plate are cumulative as well as permanent. Those on the living retina are neither. The maximum effect of a luminous object on the human eye is produced in one-tenth of a second. Beyond that limit there is continual effacement and renewal. Were it not for this faculty of rapid obliteration, we should see, with the strangest results of visual confusion between time and space, not what we were actually looking at, but what had met our eyes some short time previously. A vast gain in penetrative power would, however, ensue upon a very moderate extension of the time during which the eye can collect impressions. By lengthening it to one second the brightness of visual images would be nearly decupled, and the whole heavens would appear, like the Milky Way, dimly luminous with minute stars.*

This retentive power is possessed, in an eminent degree, by a sensitised gelatine film. No limits have, so far, been set to the time of useful exposure. Successively, as the rays continue to impinge upon it, all the orders of the stars, all the secrets of the sky, disclose themselves to its patient stare. It has thus become possible to photograph stars too faint to be seen with the same optical aid. Some of those sprinkled over the Orion nebula, in Mr. Common's beautiful picture of it, were probably beyond the reach of direct observation with the 36-inch mirror employed; and Dr. Draper at the time of his death in 1882 was making arrangements for exposing plates during nearly six hours, by which he hoped to

* Janssen "Annuaire," p. 809. Paris: 1883.

get notified of the existence of stars sunk in depths of space hopelessly inaccessible to telescopic vision.*

But the decisive impulse towards the greatest astronomical undertaking of this century came otherwise. The Royal Observatory at the Cape of Good Hope was, in 1882, unfurnished with any photographic appliances. The activity reigning there was of a rigorously orthodox kind. The ample programme of work in course of execution included nothing for which Halley or Maskelyne would have been unprepared. "Astrophysical" tendencies, of whatever description, were absent from it. Nor did any such exist in the mind of the Royal Astronomer. Dr. Gill belonged to the strict school of Bessel; in the use of the heliometer he was Bessel's legitimate successor. His leading title to distinction at that time was a masterly determination of the sun's distance, for which the opposition of Mars in 1877 had given the opportunity; and he was engaged upon a set of measures for stellar parallax of unsurpassed excellence, and now of standard authority. His energetic administration was mainly directed towards promoting the interests of practical astronomy in the southern hemisphere; and he was far from suspecting that in the camera an instrument was at hand more rapidly effective for the purpose than the transit or the heliometer. He was not, however, slow to avail himself of it.

The splendid appearance, at the Cape, of the great comet of 1882 challenged photographic portrayal; and Dr. Gill employed for that end the apparatus, and profited by the experience, of Mr. Aldis, a local artist. An ordinary portrait-lens, of only two inches aperture and eleven focus, was attached to the stand of the Observatory equatorial, the telescope itself serving as a guide to the small corrections needed of the clockwork following motion during exposures lasting from half an hour to two hours and twenty minutes. A series of pictures resulted, one of which was exhibited by Dr. Gill in the course of his lecture at the Royal Institution, cited, from its importance to our present subject, among our authorities. They were remarkable, not only for the strength and fidelity with which their principal subject was

* Rayet, "Bulletin Astronomique," tome iv. p. 320.

represented, but for the accessory wealth of stars they displayed. The entire background was thickly strewn with them. Forty or fifty, down to the ninth magnitude, shone across the interposed film of the comet's tail.

The sight of the Cape photographs set the whole astronomical world upon the business of stellar chartography. They emphasized the advantages to be derived from the use of lenses of short focus and wide field, giving small, bright images of tolerably extensive sky landscapes.* To Mr. Common they "came as a revelation of the power of photography" for star-charting purposes; and he proposed to Dr. Gould, then (in 1883) at Cordoba in South America, a joint photographic survey of the whole heavens, which it was not however found practicable just then to undertake. Investigations of relative stellar brightness by photographic means were almost simultaneously executed by Professor Pickering at Harvard and by Mr. Espin in Lancashire; and Mr. Roberts of Liverpool began, and has made considerable progress with, a detailed chart of northern stars.

But by far the most important of these preliminary enterprises was that of completing, in the southern hemisphere, the great northern star-census executed by Argelander at Bonn above a quarter of a century ago, and lately extended by Schönfeld to twenty degrees south of the equator. The "Durchmusterung," comprising in its two sections nearly 458,000 stars, may be described as the roll-call of the stellar army. Stars not entered in it have no official existence; should they fade and vanish the fact cannot be attested; should they brighten into conspicousness we are obliged to regard them as "new" for lack of previous acquaintanceship. Whatever is known of the distribution of the stars in space is founded on this grand enumeration, which was, besides, an essential prelude to more refined measurements.

A corresponding enrollment of southern stars was one of the most pressing needs of astronomy; and it is now, by novel means, in course of being supplied by Dr. Gill. His photographic "Durchmusterung" will extend from the limit of Schönfeld's zones to the south pole, and will include all stars brighter and many fainter than the ninth magnitude.

* Mr. De la Rue showed experimentally in 1861 that such instruments were the most proper for mapping the stars. "Report Brit. Ass." 1861, p. 95.

The requisite number of plates will probably have been secured in two or three years; while the catalogue derived from their measurement, through the disinterested labors of Professor Kapteyn of Groningen, may be completed in five or six. It will give the places (exact to one second of arc) and magnitudes of thirty per cent more stars per square degree than are contained in the Bonn Catalogue, and will furnish "working lists" for still more accurate determinations for about the epoch 1900.*

But we have not yet exhausted the results of the comet-pictures of 1882. Thirty-six years have elapsed since Chacornac began, at the Paris Observatory, the laborious task of charting ecliptical stars to the thirteenth magnitude. His object was the detection of asteroids, by obtaining an individual acquaintance with the small stars strewing their route in the sky; but he died in 1873, leaving the work only half finished. For its completion the resources of the newer astronomy had to be called into play.

His successors were MM. Paul and Prosper Henry, two brothers united by a rare community of tastes and endowments, inseparable in their labors, scarcely distinguishable by fame. In ten years they constructed sixteen additional maps out of a total of seventy-two; but they were arrested by encountering, where the ecliptic crosses the Milky Way, a throng of minute objects, totally unmanageable by the ordinary methods. The perplexity in which they found themselves was dissipated by a glance at the starry background of Dr. Gill's comet. They determined to have recourse to photography; their stars should henceforth register themselves. From that hour visual star-charting became a thing of the past.

The unmistakable success of some preliminary experiments earned for their scheme the warm approval of Admiral Mouchez, Director of the Paris Observatory, the title of whose valuable little book heads this article; and the construction of the largest photographic telescope yet seen was officially sanctioned. In May, 1885, an instrument on a somewhat novel plan, the optical part by the MM. Henry, was mounted in the garden of Perrault's edifice. It consists of two telescopes, one adapted for chemical, the other for

* Auwers, "Monthly Notices," vol. xlvii. p. 455.

visual use, enclosed in a single rectangular tube. The photographic objective is of thirteen inches aperture and eleven feet focus, its curves being computed to enable it to take in a wide area of the sky without sensible deformation of the images. Their complete immobility in the field is secured by a skilful use of the guiding telescope. During the time of exposure the eye of the operator is never removed from it, and incipient deviations are checked by his hand.

The results of the employment of this apparatus by the MM. Henry were summed up by Admiral Mouchez before the Academy of Sciences, January 18, 1887.

"At the Paris Observatory," he stated, "we now easily obtain, with exposures of an hour, plates upon which thousands of stars down to the sixteenth magnitude are portrayed with the utmost nicety and distinctness over an area of six or seven square degrees. That is to say, the limit of visibility with our best telescopes under the sky of Paris is considerably overpassed, and we have even obtained many seventeenth magnitude stars doubtless never anywhere directly observed. The stellar images, varying in diameter proportionately to magnitude, afford useful data for photometric determinations.

"Objects other than stars, invisible in our most powerful instruments, sometimes appear on the plates. Such is the Maia nebula in the Pleiades, depicted like the tail of a brilliant little comet attached to the star, yet heretofore undetected, notwithstanding the exceptional amount of attention bestowed upon the Pleiades group. Unknown bodies, in sufficiently rapid movement to become sensibly displaced in an hour—minor planets, for instance, comets, the problematical trans-Neptunian planet, or undiscovered satellites—may reveal their existence by imprinting the line of their route among the fixed stars, as Pallas has been observed to do.

"The distinct visibility, on a photograph submitted to the Academy, of the interval of 0″.4 between the rings of Saturn, gives a prospect of securing impressions of double stars at that apparent distance. The satellite of Neptune has been photographed in every part of its orbit, even when it is only 8″ from the planet.*

"With the consideration before us that the stars below the sixteenth magnitude have thus been photographed amid the turbid atmosphere of Paris, it becomes difficult to imagine the prodigious quantity of new objects which would be disclosed on the plates of the MM. Henry could they be exposed under the pure skies of the tropics, or at so favourable a station as the Pic du Midi. Stars of the eighteenth magnitude would then not improbably emerge to view, showing a penetration of the heavens to depths never before sounded. Such plates would doubtless, at a little distance, like the firmament itself in serene tropical nights, assume a uniformly nebulous aspect. We hope then to apply photography not only to the regular prosecution of celestial chartography, but to researches on double stars, and to explorations in search of unknown heavenly bodies."†

* No visual observations of Neptune's satellite have ever been made at Paris.

† Mouchez, "La Photographie Astronomique," p. 37.

Specimens of the Paris photographs were soon in the hands of astronomers in all parts of the world. They were received with admiration not unmixed with incredulity. They seemed too absolutely perfect to be wholly genuine. Abundant evidence was however at hand to show that their extraordinary precision was really the fruit of unparalleled skill, and this conviction, once attained, was decisive of the future of astronomy.

On one of the plates, covering an area of about four square degrees in the constellation Cygnus, where 170 stars had previously been identified, some 5,000 were clearly imprinted. Wolf's great map of the Pleiades, founded on laborious servations extending over several years, contains 671 stars; photographs taken in a few hours by the MM. Henry supplied materials for charting 1,421 stars of the same group down to the sixteenth magnitude with an exactitude unattainable by visual means. The significance of such results was not to be mistaken. They pointed to a great task, the execution of which was felt to be imperative so soon as it had become possible; and Dr. Gill gave expression to a universal sentiment when he proposed, June 4, 1886, an International Congress for the purpose of organising a photographic survey on a grand scale of the entire heavens.

Fifty-five delegates of fifteen different nationalities took part in the deliberations of the memorable assembly which met at Paris, April 16, 1887. They were concluded in nine days, and were as harmonious as they were prompt. Enthusiasm for a great end secured unanimity as to the means; differences of opinion vanished as if under the pressure of some supreme crisis. The upshot of the meetings was to set preparations on foot for the charting of over twenty millions of stars! So far have we got by the aid of photography.

The co-öperation of ten or twelve observatories in both hemispheres can be reckoned upon, and the work will be executed upon an identical plan with instruments similar in every respect to that of the MM. Henry. About ten thousand plates (duplicated to avoid accidental errors), each exposed during a quarter of an hour, will record the positions of all the stars in the sky to the fourteenth magnitude—the prescribed limit of faintness. This part of the undertaking

can scarcely occupy less than five years. For the orientation of each plate, a single "star-trail" (necessarily running along a parallel of declination) will suffice. The *absolute* places of the imprinted stars will be deduced from accurate measurements of their situations relative to certain "standard stars," of which a sufficient number will be found on every plate.

But there is to be a catalogue as well as a chart, and, in Dr. Gill's opinion, "the work which astronomers of future generations will be most grateful for, and which will most powerfully conduce to the progress of astronomy, will *not* be the chart but the catalogue." Plates showing fourteenth magnitude stars, however, are necessarily over-exposed for the brighter ones, and are hence not available for the most refined determinations. A set of short-exposure plates, reaching to the eleventh magnitude, are accordingly to be taken with a view to cataloguing about one million and a half stars to serve as reference-points for the twenty millions crowded on the chart plates. Such a catalogue (we again quote Dr. Gill) "may be considered complete for the practical purposes of astronomy, because the eleventh magnitude is the faintest which can be measured with accuracy in the larger class of equatorials usually employed in working observatories."

The mass of stellar statistics thus collected will include data as to relative brightness. The "magnitudes" of stars can be derived from photographs either by comparing the size of their images on the same plate, or by measuring the time that elapses before they produce a sensible impression. Estimates founded on the circumstance that the diameters of the photographic discs of stars bear a strict ratio to their lustre have proved accurate (on an average) to one-fifth of a magnitude; and varying length of exposure affords the only fixed standard of brightness at present available for the minuter orders of stars. The photometric range of the eye is somewhat narrowly limited, and large errors attest its incompetence below the eleventh or twelfth magnitude. The sensitive plate, on the other hand, measuring light-intensity as it were by the clock, records its gradations between faint objects more precisely than between bright, because the corresponding intervals of time are larger. Stars of the first,

second, and third magnitudes can all be photographed in a small fraction of a second; but stars of the thirteenth magnitude require five, of the fourteenth thirteen, of the sixteenth eighty minutes, before they become perceptible with the apparatus of the MM. Henry. Intermediate positions on the photometric scale can hence, it is obvious, be assigned much more easily and securely towards its lower end.

(TO BE CONTINUED.)

THE COMETS OF 1887.

DR. H. C. WILSON.*

For the MESSENGER.

The authorities referred to in this paper are the *Astronomische Nachrichten* (A. N.), *Astronomical Journal* (A. J.), *Bulletin Astronomique* (B. A.), *Monthly Notices of the Royal Astronomical Society* (M. N.), and SIDEREAL MESSENGER (S. M.). The numbers of volume and page are both given in figures but are separated by periods. Different pages of the same volume are separated by commas, and different volumes by the semicolon. Thus A. N. 117. 293, 307; 118. 109, means *Astronomische Nachrichten*, vol. 117, pp. 293 and 307; vol. 118. p. 109. I have endeavored to collect references to all of the observations published in the above journals, and to give the dates of the first and last observation at each place.

Comet 1886 VII (Finlay *e* 1886, Sept. 26). This comet was observed during the last three months of 1886 and the first two months of 1887. The first elements determined of the orbit of this comet bore such a resemblance to those of the lost comet of De Vico, 1844 I, that the two were thought to be identical. The later computations by Professor Krueger and Professor Boss render the identity very doubtful (see further upon this point *Astr. Nach.* 116. 335, *Astr. Jour.* 7. 43, and *Sid. Mess.* 6. 121). The elements by Professor Krueger depend upon observations from Sept. 29, 1886, to Feb. 23, 1887, and are as follows:

$T = 1886$, Nov. 22.38708 Greenwich mean time.

$\left.\begin{aligned} \pi &= 7°\,34'\,14.6'' \\ \Omega &= 52\ 29\ 58.8 \\ i &= 3\ 01\ 39.2 \end{aligned}\right\}$ 1886.0.

$\varphi = 45\ 54\ 22.7$

$\mu = 532''.6894.$

Period $= 2432.937$ days.

* Carleton College Observatory.

The following observations have been published:

Albany, Sept. 29—Feb. 25, A. J. 7. 21, 52, 84.
Alger, Dec. 11—Jan. 25, B. A. 4. 136.
Berlin, Dec. 17, A. N. 117. 171.
Bethlehem, Pa., Oct. 16—Jan. 26, A. J. 7. 54, 61.
Bordeaux, Nov. 24—Dec. 30, A. N. 117. 99.
Brussels, Nov. 22—Jan. 17, A. N. 117. 145.
Cape, Sept. 26—Dec. 28, M. N. 47. 290; A. N. 116. 309.
Cordoba, Oct. 14—Jan. 27, A. N. 117. 271; A. J. 7. 117.
Dresden, Nov. 27—Feb. 12, A. N. 116. 43, 111, 247.
Genf, Sept. 29—Feb. 10, A. N. 117. 41.
Glasgow, Nov. 12—Feb. 24, A. N. 117. 113.
Gottingen, Jan. 18, A. N. 116. 219.
Greenwich, Jan. 16—25, M. N. 47. 275.
Hamburg, Dec. 18—Jan. 23, A. N. 116. 111, 219.
Kiel, Nov. 22—Feb. 11, A. N. 116. 13, 77, 111, 127, 219.
Kopenhagen, Dec. 19—Mar. 16, A. N. 118. 73.
Kremsmunster, Oct. 23—Jan. 27, A. N. 116. 41; 117. 147.
Lyon, Nov. 12—Dec. 23, B. A. 4. 100.
Milan, Dec. 12—Jan. 28, A. N. 117. 163.
Nice, Sept. 29—Dec. 6, A. N. 115. 239; 116. 151; B. A. 4. 134.
Orwell Park, Nov. 18—Feb. 25, M. N. 48. 55.
Padua, Nov. 19—Dec. 26, A. N. 116. 215.
Palermo, Nov. 17—Dec. 18, A. N. 116. 151, 263.
Plonsk, Nov. 26—Jan. 25, A. N. 116. 261.
Pola, Oct. 23—25, A. N. 116. 193.
Princeton, Dec. 16—Feb. 19, A. J. 7. 110.
Rome, Sept. 29—Feb. 25, A. N. 115. 237, 253, 267, 283, 303; 116. 27, 43, 331.
Sydney, Sept. 30—Oct. 12, M. N. 47. 68.
Taschkent, Oct. 28—Nov. 18, A. N. 116. 247.
Turin, Oct. 22—Dec. 23, A. N. 115. 397; 116. 153; 117. 115.
Washington, Sept. 30—Feb. 16, A. J. 7. 8, 31, 62, 78.
Wien, Sept. 30—Dec. 26, A. N. 116. 347.
Windsor, Oct. 8—Dec. 30, A. N. 117. 109.

Comet 1886 VIII (Barnard *c* 1887, Jan. 23). This was the third comet discovered in 1887, but had already passed its perihelion Nov. 28, 1886. It was discovered by Mr. E. E. Barnard, of Nashville, Tenn., on the morning of Jan. 24, a dim hazy object several degrees southwest of β Cygni, circular, 1′ in diameter, with some central condensation. It moved northward, diminishing slowly in brightness, the last published observation being at Orwell Park, May 20. The latest published elements are by Mr. H. V. Egbert (A. J. 7. 87) and depend upon only three single observations, on the dates Jan. 24, Feb. 18, and March 20.

$$T = 1886, \text{Nov. } 28.37512, \text{ Greenwich mean time.}$$
$$\left.\begin{aligned} \omega &= 31^\circ 53' 16'' \\ \Omega &= 258\ 11\ 58 \\ i &= 85\ 35\ 18 \end{aligned}\right\} 1887.0.$$
$$\log q = 0.170274.$$

Observations:

Albany, Jan. 24—Mar. 26, A. J. 7. 56, 83.
Alger, Jan. 27—Feb. 5, B. A. 4. 137.
Bordeaux, Jan. 26—Mar. 4, A. N. 116. 157; 117. 99.
Cambridge, Jan. 24, A. N. 116. 191.
Dresden, April 27, A. N. 117. 41.
Gottingen, Jan. 25, A. N. 116. 157.
Greenwich, Feb. 28, M. N. 47. 275.
Hamburg, Feb. 17—18, A. N. 116. 249.
Konigsberg, Jan. 25, A. N. 116. 159.
Kopenhagen, Feb. 13—16, A. N. 118. 73.
Kremsmunster, Jan. 28—Mar. 24, A. N. 118. 105.
Nashville, Jan. 23—30, A. N. 116. 251; A. J. 7. 63, 79.
Nice, Jan. 26—Apr. 27, B. A. 4. 58, 194; A. N. 117. 41.
Orwell Park, Feb. 13—May 20, M. N. 48. 56.
Padua, Jan. 28—30, A. N. 116. 171.
Palermo, Jan. 26-27, A. N. 116. 157, 159.
Paris, Jan. 27, A. N. 116. 159.
Scarborough, Feb. 3, A. N. 116. 175.
Wien, Jan. 27—Mar. 31, A. N. 116. 159, 191, 367; 117. 41.

Comet 1886 IX (Barnard-Hartwig, *f* 1886, Oct. 4). This comet became invisible to observers in the northern hemisphere early in January, 1887, but was followed in the southern hemisphere until the middle of June. The following set of elements computed by Lieut. Wm. H. Allen, U. S. Navy, (A. J. 7.55) from four normal places, of dates Oct. 8.0, Nov. 3.5, Dec. 2.5 and Dec. 10.0, represent the observations fairly well:

$$\left.\begin{aligned} T &= 1886\ \text{Dec. } 16.50579\ \text{Greenwich mean time.} \\ \omega &= 86^\circ\ 21'\ 33.1'' \\ \Omega &= 137\ \ 22\ \ 36.8 \\ i &= 101\ \ 36\ \ 55.5 \end{aligned}\right\} 1886.0$$

$$\log q = 9.821628$$

Observations:

Albany, Oct. 6—Nov. 1, A. J. 7. 98.
Alger, Nov. 11—Jan. 3, B. A. 3. 586; 4. 136.
Bothkamp, Oct. 29—Dec. 2, A. N. 115. 283; 116. 125.
Brussels, Oct. 22—Dec. 20, A. N. 117. 145.
Cape, April 29—June 16, A. N. 117. 339.
Dresden, Dec. 26—Jan. 8, A. N. 116. 247.
Gotha, Oct. 28—Dec. 29, A. N. 115. 317; 116. 171.
Greenwich, Nov. 2—Dec. 16, M. N. 47. 27, 65, 116; 48. 116.
Hamburg, Oct. 27, 28, A. N. 115. 283.
Harrow, Dec. 19—Jan. 5, M. N. 47. 549.
Kiel, Oct. 27—Dec. 10, A. N. 115. 283, 317; 116. 125.
Kopenhagen, Oct. 6—Dec. 31, A. N. 115. 253; 117. 11.
Kremsmunster, Oct. 9—Dec. 2, A. N. 116. 43; 117. 147.
Liege, Oct. 31, A. N. 115. 317.
Lyon, Oct. 7—10, B. A. 4. 100.
Marseille, Oct. 7—11, B. A. 3. 533.
Milan, Dec. 5—Jan. 13, A. N. 117. 163.
Nice, Oct. 29,—Dec. 23, B. A. 4. 134.
Orwell Park, Oct. 22—Jan. 10, M. N. 48. 57.
Padua, Nov. 28—Dec. 28, A. N. 116. 215.
Palermo, Oct. 9—Dec. 27, A. N. 115. 255, 267; 116. 27, 329.
Pola, Oct. 30—Nov. 2, A. N. 116. 193.
Prag, Oct. 9—Dec. 5, A. N. 115. 255; 116. 155.
Strassburg, Oct. 24, A. N. 115. 285.
Turin, Oct. 30—Dec. 4, A. N. 115. 397; 116. 153; 117. 117.
Washington, Oct. 7—Dec. 10, A. J. 7. 8, 31.
Wien, Oct. 7—28, A. N. 115. 253; 116. 347.

Comet 1887 I (*a* 1887, June 18). This comet appeared suddenly in the southern hemisphere, and was discovered by several persons at different places on the same night Jan. 18, and by others on subsequent nights. It was described by Mr. Finlay as presenting the appearance of a pale, narrow ribbon of light, quite straight and of nearly uniform brightness throughout its length. There was no head or condensation of any kind near the end, the light simply fading away to nothing. According to Dr. Thome of the Cordoba Observatory "the tail steadily grew in apparent brightness and length as the comet increased its distance from the horizon until Jan. 25, when it became evident that it had been fading from the first." Mr. Finlay of the Cape of Good Hope Observatory and Mr. Todd of the Adelaide Observatory both speak of this comet as resembling very closely in appearance the comet of February 1880, which during its short season of visibility occupied the same part of the sky and came into view equally suddenly. Considerable difficulty has been encountered in attempting to compute the orbit of this comet because of the uncertainty of the observed positions, there being no well defined nucleus or even head upon which observers could point the telescope. Entirely different sets of elements may be obtained from the observations made by different observers. The following table gives the elements which have been published. The first set depend upon observations made at Melbourne, Windsor and Cordoba, the second upon those at Cordoba alone, the third upon those at the Cape alone, and the last two upon the observations at the Cape and Adelaide observatories:

T. Gr. mean time.	Ω	ω	i	log. q.	Computer.	Reference.
1887 Jan. 8.730	132°49′	174°49′	57°52′	8.3628	Chandler.	A. J. 7.92
1887 Jan. 8.825	315 36	234 18	115 35	9.2938	Thome.	A. J. 7.91
1887 Jan. 11.244	359 41	90 00	141 16	8.1644	Finlay.	M. N. 47.303
1887 Jan. 11.230	337 43	63 36	137 00	7.7389	Chandler.	A. J. 7.100
1887 Jan. 11.415	339 52	64 40	138 02	7,6666	Oppenheim.	A.N.117.13

The last three sets of elements bear some resemblance to those of the remarkable group of great comets of 1843, 1880 and 1882, each of which approached very close to the sun. Dr. H. Oppenheim thinks that this may be another member of that comet system (A. N. 117. 16).

Observations:

Adelaide, Jan. 21-27, M. N. 47. 305.
Cape, Jan. 22-28, M. N. 47. 303.
Cordoba, Jan. 20-27, A. J. 7. 91; 117. 259.
Melbourne, Jan. 23-24, A.N. 116. 143.
Windsor, Jan. 28, 30, A.N. 116. 319.
Sextant observations on board ship, Jan. 21-25, M. N. 47. 432.

The comet was observed only ten days after discovery, full moonlight then rendering it invisible. After the moon had passed from that part of the sky, no trace of the comet could be found.

On February 13, Professor Swift of the Warner Observatory at Rochester, New York, found two objects, one of which he thought to be the comet, in R. A. $3^h\ 33^m$ and Decl. $-37°35'$, about -38^m and $+4°$ from the computed place of of the comet. They are designated as Nos. 14 and 15 of Catalogue No. 6 of nebulæ discovered at the Warner Observatory (A. N. 117. 217). As a long period of cloudy weather followed, Professor Swift was unable then to verify his observation, but in November, 1887, Mr. E. E. Barnard while at the Davidson Observatory, California, examined that part of the sky with an eight-inch telescope, and found nothing. He did find, however, two known nebulæ, G. C. 697 and 698, in R. A. $3^h\ 18^m$, Decl. $-37°36'$, which answer exactly Swift's description of his Nos. 14 and 15 (A. N. 118.1 73). It seems probable, therefore, that these known nebulæ were the objects which Swift observed, and that the R. A. given in his catalogue No. 6 is 15^m too great.

Comet 1887 II (Brooks *b* 1887 Jan. 22). Discovered by Mr. W. R. Brooks at Phelps, N. Y., on the evening of January 22, in the constellation of Draco. It was then round, with some central condensation, and easily visible with moderate apertures. It attained its greatest brilliancy about the middle of February, and vanished from view in April. The following elements by Professor Boss were derived from observations made Jan. 24, Feb. 15, and March 12 (A. J. 7. 85):

$$T = 1887 \text{ March } 16.9819 \text{ Greenwich mean time.}$$
$$\left.\begin{aligned} \omega &= 159°\ 09'\ 00'' \\ \Omega &= 279\ \ 49\ \ 58 \\ i &= 104\ \ 18\ \ 19 \end{aligned}\right\} 1887.0$$
$$\log q = 0.213070. \quad \Delta\lambda \cos\beta = +\ 9.0''; \quad \Delta\beta = -4.1''.$$

The orbit does not differ materially from a parabola.

Observations:

Albany, Jan. 24—March. 12, A. J. 7. 56, 61, 85.
Alger, Jan. 27—April 14, B. A. 4. 136, 423.
Bethlehem, Pa., Feb. 9-19, A. J. 7. 80.
Berlin, Feb. 11, A. N. 116. 189.
Bordeaux, Jan. 29—March 30, A. N. 116. 157; 117. 99.
Cambridge, Jan. 24-27, A. N. 116. 191.
Dresden, Feb. 15—March 24, A. N. 116. 203, 249, 267, 317, 327.
Genf, Feb. 10—April 20, A. N. 116. 333; 117. 55.
Gottingen, Feb. 15—March 15, A. N. 116. 203, 219, 249, 267; 117. 149.
Greenwich, Feb. 27— M. N. 47. 275, 392.
Hamburg, Feb. 13-15, A. N. 116. 203.
Kiel, Jan. 27—Feb. 15, A. N. 116. 157, 189, 203.
Kopenhagen, Feb. 13—March 16, A. N. 118. 73.
Kremsmunster, Jan. 24—March 21, A. N. 117. 149; 118. 105.
Milan, Jan. 27, A. N. 116. 173.
Nashville, Jan. 23, A. N. 116. 203; A. J. 7. 63.
Nice, Jan. 27-29, B. A. 4. 135.
Padua, Jan. 27-30, A. N. 116. 171.
Palermo, Jan. 29—Feb. 24, A. N. 116. 219, 265.
Paris, Jan. 27, A. N. 116. 173.
Plonsk, Feb. 11-25, A. N. 117. 305.
Strassburg, Jan. 26—Feb. 11, A. N. 116. 143, 157, 203.
Washington, Jan. 24—March 12, A. J. 7. 62, 78, 86.
Wien, Jan. 28—Feb. 12, A. N. 116. 173, 203, 205.

Comet 1887 III (Barnard *d* 1887 Feb. 16). Discovered by Mr. E. E. Barnard at Nashville on the night of Feb. 16. It was very faint and had a very rapid apparent motion. The last observation was made April 10 at Orwell Park Observatory. Mr. Barnard has computed the following elements of the orbit of this comet from his own observations of Feb. 16, Feb. 28 and March 12:

$$T = 1887 \text{ March } 28.39633 \text{ Greenwich mean time.}$$
$$\left.\begin{aligned} \omega &= 36^\circ 28' 50'' \\ \Omega &= 135\ \ 27\ 17 \\ \iota &= 139\ \ 48\ 39 \end{aligned}\right\} 1887.0$$
$$\log q = 0.00295$$

Observations:

Albany, Feb. 19—25, A. J. 7. 84.
Alger, Feb. 24—March 25, B. A. 4. 137, 423.
Berlin, Feb. 28, A. N. 116. 251.
Cambridge, Feb. 17—28, A. J. 7. 79; A. N. 116. 267.
Dresden, Feb. 24—March 24, A. N. 116. 221, 267, 317.
Genf, Feb. 24—March 18, A. N. 116. 251, 315.
Gottingen, Feb. 24, A. N. 116. 221.
Greenwich, Feb. 28, M. N. 47. 275.
Hamburg, Feb. 26, A. N. 116. 221.
Kremsmunster, Feb. 24—25, A. N. 117. 149.
Kopenhagen, March 16, A. N. 118. 73.
Nashville, Feb. 16—22, A. J. 7. 79; A. N. 116. 251.
Nice, Feb. 28—March 1, B. A. 4. 194.
Orwell Park, Feb. 28—April 10, M. N. 48. 61.
Palermo, Feb. 27, A. N. 116. 267
Paris, Feb. 17, A. N. 116. 207
Rome, Feb. 24—25, A. N. 116. 251; 117. 269.
Strassburg, Feb. 23—March 14, A. N. 116. 221, 267.
Wien, Feb. 24—28, A. N. 116. 221, 251.

Comet 1887 IV (Barnard *e* 1887 May 12) was also discovered by Mr. E. E. Barnard. It was described by Profes-

sor Boss on May 13 as extremely condensed, with a star-like nucleus of the 11.5 magnitude. It attained its greatest brilliancy, which was only 1.6 times its brightness when discovered, in June, and was lost to sight in August. Mr. S. C. Chandler (A. J. 7. 104) has computed the following elements from seventeen observations, combined into four normal places, extending from May 12 to May 30:

T = June 16.73745 Greenwich mean time.
ω = 15° 11′ 53.6″
Ω = 245 13 01.9 } 1887.0
ι = 17 35 18.4
$\log q = 0.144408$.

Observations:

Albany, May 13-23, A. J. 7. 103.
Alger, May 16—Aug. 9, A. N. 117. 57; B. A. 4. 424, 465.
Berlin, May 23—June 26, A. N. 117. 43, 385; 118. 285.
Bordeaux, May 22—Aug. 10, A. N. 117. 151, 307.
Bothkamp, June 15—July 25, A. N. 117. 133, 215.
Cambridge, May 13—July 12. A. J. 7. 111, 119, 152; A. N. 117. 243.
Cape, May 19—June 17, A. N. 117. 339.
Dresden, May 19—July 16, A. N. 117. 43, 59, 133, 215.
Genf, May 10—June 30, A. N. 117. 43; 118. 239.
Gottingen, June 15, A. N. 117. 133.
Gohlis, June 13-25, A. N. 117. 213.
Greenwich, June 12-19, A. N. 117. 215.
Hamburg, June 16-19, A. N. 117. 133.
Harrow, June 12-22, M. N. 47. 550.
Kiel, May 14-21, A. N. 117. 31, 43.
Kremsmunster, May 15—July 12, A. N. 118. 107.
Marseille, May 14–June 28, B. A. 4. 462.
Nashville, May 12—Aug. 11, A. N. 117. 31, 57, 243, 385; A. J. 7. 103.
Nice, May 14- —, B. A. 4. 225, 380; A. N. 117. 43.
Nicolaiew, May 14-21, A. N. 117. 55.
Orwell Park, June 9—July 28, M. N. 48. 61.
Padua, May 14—June 23, A. N. 117. 43, 101; 118. 233.
Palermo, May 15-31, A. N. 117. 31, 59, 101.
Paris, May 14, A. N. 117. 43.
Prag, May 27, A. N. 117. 59.
Rome, May 14—Aug. 7, A. N. 117. 43, 269, 275.
Scarborough, May 20-29, M. N. 47. 498.
Strassburg, May 15, A. N. 117. 31.
Wien, May 15-17, A. N. 117. 43.

Comet 1887 V (Olbers-Brooks *f* 1887 Aug. 24). This comet was discovered by Mr. W. R. Brooks at Phelps N. Y., on the morning of August 25, in the constellation of Cancer. The first set of elements, computed by Mr. H. V. Egbert at Albany, established its identity with the Olbers' comet of 1815, the return of which was expected sometime in 1886 or 1887. Bessel computed an elliptic orbit from 187 observations at the apparition of 1815, obtaining a period of 70.049 years. He anticipated that planetary perturbations would bring it back to perihelion Feb. 9, 1887. A new investigation was undertaken in 1879 by Mr. F. K. Ginzel, in response to the offer of a prize by the Holland "Gesellschaft

der Wissensschaften" and his results were published in 1881 by that society. He re-reduced many of the observations and computed the perturbations by all of the planets and derived a period of from 72⅓ to 75⅔ years. He assigned as the most probable date of perihelion passage Dec. 17, 1886 ± 1.6 years (A. J. 100. 75 and 109. 321) and computed a sweeping ephemeris for the last three months of the year. The perihelion passage actually occurred Oct. 8, 1887, giving a period of 72.45 years.

On August 25, Mr. Brooks described the comet as brightish with eccentric condensation. Later a short tail was developed. Its greatest brightness was attained in October. The comet is still in favorable position, although very faint, and may be followed for some time longer.

Mr. Ginzel has derived the following elements, using observations of Aug. 27, Sept. 6, and Sept. 14 to determine the corrections to the semimajor axis and perihelion time (A. J. 118. 389):

$$T = 1887 \text{ Oct. } 8.40998 \text{ Greenwich mean time.}$$
$$\left.\begin{aligned} \omega &= 65^\circ\ 16'\ 06.5'' \\ \Omega &= 84\ \ 29\ \ 40.8 \\ i &= 44\ \ 33\ \ 53.0 \end{aligned}\right\} 1887.0$$
$$\varphi = 68\ \ 36\ \ 23.8$$
$$\log q = 0.079040$$
$$\log a = 1.240743$$
$$\mu = 48.85311''$$

He intends to pursue farther the investigation of this orbit.

Observations:

Albany, Aug. 26—Nov. 1, A. J. 7. 128, 136, 152.
Alger, Aug. 29—Sept. 22, A. N. 117. 325; B. A. 4. 466.
Besancon, Aug. 29—Sept. 1, A. N. 117. 341.
Bordeaux, Sept. 8—25, A. N. 118. 109.
Bothkamp, Sept. 18—Jan. 18. A. N. 117. 387; 118. 287.
Dresden, Jan. 25, A. N. 118. 271.
Genf, Aug. 29—Nov. 4, A. N. 117. 293, 307; 118. 109.
Hamburg, Sept. 20—24, A. N. 117. 355, 387.
Kiel, Sept. 14—20, A. N. 117. 327, 341, 355.
Konigsberg, Aug. 27—Nov. 11, A. N. 117. 295, 341, 387; 118. 41, 94.
Kremsmunster, Aug. 28—Sept. 17, A. N. 117. 293; 118. 107.
Leipzig, Sept. 15—26, A. N. 118. 249.
Marseille, Aug. 27—Sept. 26, B. A. 4. 462, 464.
Milan, Aug. 30—31, A. N. 117. 307.
Nice, Aug. 29—Sept. 26, B. A. 4. 467.
Orwell Park, Dec. 6—18, A. N. 118. 207.
Padua, Sept. 13—Nov. 17, A. N. 117. 389; 118. 233.
Plonsk, Sept. 6, A. N. 117. 327, 391.
Pulkowa, Sept. 25—Nov. 15, A. N. 118. 109.
Rome, Aug. 27, A. N. 117. 293.
Strassburg, Aug. 27—Sept. 14, A. N. 117. 293, 341.
Turin, Aug. 29—31, A. N. 117. 293, 327.
Wien, Aug. 27—Oct. 21, A. N. 117. 293; 118. 45.

TOTAL SOLAR ECLIPSE, AUG. 19, 1887.*

DR. B. VON ENGLEHARDT, DRESDEN.

For the MESSENGER.

The following abstract is taken from the interesting report of Dr. Khandrikoff, professor of astronomy in the Prussian Imperial University at Kiew:

The total eclipse of this year, the calculation of which twenty-five years ago was the subject of his doctor's thesis, was observed by him at Mount Blaghodat, an isolated peak in the most eastern part of the Ural Mountains. This mountain lies in latitude 58°17′20″ north, and longitude 3*h* 59*m* 10*s* east of Greenwich, and was near the central line of totality of the eclipse. For the observation he used a three and one-half-inch telescope, with a micrometer, a chronometer, and a sextant.

During eleven days before the eclipse the rate of the chronometer was tested, and the surface of the sun repeatedly observed. During the eclipse four points of astronomical interest were very distinctly noted: the first contact, the beginning and end of the totality, and the last contact, as well as two obscurations of small sun spots.

But the chief interest was not in the astronomical, but in the astrophysical observation. As the black disc of the moon passed over the sun the contour of the mountains of the moon could be accurately noted by means of the steady and sharp images in the telescope. Until the disc of the sun was half covered the decrease of light was not manifested, at least not as strongly as reported by many observers of former eclipses. A rapid but not especially remarkable decrease of light began only ten minutes before totality, and, at the same time a yellowish coloring of all objects was distinctly perceived. The white paper lying before the observer appeared yellowish red. Fifteen seconds before totality the narrow crescent of the sun was notched by the mountains of the moon, and the northeastern cusp was strongly blunted. In this place, a short distance from cusp, the outlines of the disc of the moon could be perceived beyond the sun, because it projected itself upon the lower part of the

* This interesting account of the total solar eclipse of Aug. 19, 1887, from Dr. B. von Englehardt of Dresden, has been translated from the German, for the benefit of the readers of THE MESSENGER.

corona. These appearances were not noticed in relation to the other cusp.

It is difficult to represent the sensations at the moment of totality. With the disappearance of the last points of sunlight a wonderful halo flamed up around the entire dark disk of the moon; the shining corona appeared in a silver blaze with differently colored rays or bands of light and the protuberances were painted in hues not found on any painter's palette. These wonderful tongues of fire were of a bluish-red color and possessed the transparency of a delicate flame.

In the first moment of totality four protuberances were visible on the eastern limit of the sun. The most southern had the greatest dimensions and could be seen even with the naked eye. By the progress of the moon three of the protuberances were covered, but the most southerly one remained visible until the end of totality. Their size was colossal, reaching to about one-third the radius of the sun.

The light of the corona was strong only to a distance of one or two minutes of arc from the limit of the moon, and its intensity was not uniform. The directions of the bands of light of the corona varied considerably. Some extended in the direction of the radii of the sun, some made varying angles, and others were perpendicular to the radii. The most important of these had an expansion of at least twice the radius. Also the forms were varied. Two were lenticular and consisted of converging rays. All the rays of the corona had an intense silver blaze, were steady and retained their form and position unchanged during the entire totality.

The four colored pictures finished in oil and which were sent with the Professor's report, show the appearances at four different moments, given in local time. Plate I is taken shortly before the beginning of totality. Plate II shows the phenomenon at the moment of totality. Plate III, at the middle, and Plate IV a short time before the end. The pictures in Krasnojarsk (Siberia) received from the expedition of the Russian Imperial Physico-Chemical Society are identical with these.

About forty seconds before the end of totality an important group of protuberances having a breadth of at least sixty degrees, appeared upon the western edge. They were seen late because they were so very low.

There was no time to count the stars visible to the naked eye in the immediate neighborhood of the sun. Still Venus was seen on the left, and Mercury and Mars upon the right of the sun. Besides, the star α Leonis was visible almost in the rays of the corona, from which it may be concluded that the light of the corona is less than that of the full moon, because α Leonis would be seen with difficulty at the same distance from the bright moon.

During totality it was so dark that neither notes nor chronometer could be read without a lantern.

The decrease of temperature during totality did not exceed one degree.

The Professor is inclined to the opinion that the phenomena observed by him are somewhat opposed to the present theories of the constitution of the sun. It is commonly believed that a close relation exists between the sun spots, faculæ and protuberances. According to Faye the spots are funnel-shaped vortices into which the relatively cold hydrogen of the chromosphere is drawn, and through which, the faculæ are originated. After the hydrogen has reached a certain depth it rises again on account of the heat. Sometimes the glowing hydrogen breaks out violently, like the outburst of a volcano, and becomes visible in the form of a protuberance. In the year 1887, we were near the minimum of the sun-spots (the next minimum occurs in 1889); during the eleven days before the eclipse only a few sun spots were to be seen; and consequently we should expect to see scarcely any protuberances. But on the contrary, the sun was rich in beautiful and large protuberances, which opposes the theory of a relation between the sun-spots and the protuberances. But still more puzzling is the corona and especially the rays or bands of its light which form different angles with the directions of the radii of the sun. Possibly these appearances could be explained in this way; that the surface of the moon, strongly reflecting the sunlight, is so uneven that, like the facets of the diamond, it turns the sunlight in different directions. Through the reflection of the sunlight from the formations very near the limb of the moon, rays can be turned from the direction of the sun's radii, and even be made curvilinear.

From his observations the Professor comes to the following conclusions:

I. Between the sun-spots and the protuberances there is no immediate relation, at least not the relation which Faye assumes in his hypothesis, on the structure of the sun.

II. The corona does not consist of matter but is a light-phenomenon which, perhaps, takes place on the surface of the moon, and is brought to our eye through the mediation of the earth's atmosphere.

FOR STUDENTS AND YOUNG OBSERVERS.

Interesting Phenomena for April.

THE PLANETS.

Mercury will not be in very favorable position for observation in the northern hemisphere during this month, because his declination is more south than that of the sun. He may be seen, perhaps, about an hour before sunrise when the atmosphere is exceptionally clear toward the east. He will be in conjunction with Venus at midday on the 13th, being then 1°10′ south of the latter. The diameter of this planet will decrease during the month from 7.2″ to 5.2″ while its brilliancy will increase from one-half to about two-thirds of that when it was so well seen in the middle of February.

Venus is in nearly the same right ascension as Mercury, but, being so much brighter, will be seen without difficulty, rising a little more than an hour before the sun. Venus will be in aphelion, *i. e.*, at greatest distance from the sun, April 2, in conjunction with the moon, north 2°23′, on the evening of the 8th. Her brilliancy is slowly decreasing, although her phase increases from 0.892 to 0.944 during the month.

Mars comes to opposition on the 10th of this month, so that its disc will be full at that time. Its nearest approach to the earth will be on the 16th, when Mars will be about 56,000,000 miles from the earth and 149,000,000 miles from the sun. It will be remembered that the orbit of Mars is quite excentric and that its distance from the earth at opposition varies from 33,000,000 to 62,000,000 miles. Comparing these numbers it will be seen that the present opposition is one of the least favorable for the study of minute details of surface markings.

Jupiter is coming into position for evening observation, rising at 9 P. M., at the end of the month. His polar diameter is 39.9″ on the first, and 42.4″ on the last day of the month. The number of phenomena of the satellites to be observed this month appears to be rather greater than usual. Observers will do well to watch carefully the appearance of the different satellites while in transit across the disk of the planet. It is found that they differ from each other in the appearance presented during transit. The second satellite always appears bright, *i. e.*, brighter than the face of the planet upon which it is projected, during the whole transit. The third sometimes disappears after entering a certain distance upon the disk and reappears as a dark spot; disappears again and reappears white before leaving the disk; at other times remains white throughout the transit. The first and fourth always disappear, and reappear as dark spots, the first generally turning light steel gray, but sometimes dusky or almost black. The fourth is usually bright for the first ten or fifteen minutes of transit, then lost for about the same time, reappears as a dark spot, becoming jet black; in passing off the disk, the phenomena occur in the reverse order. In the *Monthly Notices of the Royal Astronomical Society*, for November, 1887 (Vol. 48, p. 32), there is an interesting paper upon this subject by Mr. E. J. Spitta, in which, it seems to us, the author has given a very satisfactory explanation of the phenomena of dark transits.

Saturn will be in quadrature on the 18th. Many of our readers doubtless have noticed his retrograde motion during the last few months, by the flattening of the triangle formed by Saturn with the two pairs of bright stars in Gemini and Canis Minor. The motion this month will be in the opposite direction. We have obtained several exquisite views of this planet with the 8¼-inch refractor during the past month. The three rings and the white equatorial belt were nicely shown and glimpses were obtained of the Encke division of the outer ring and of narrow belts and mottlings on the southern hemisphere of the planet.

Uranus on the first of the month is 39*m* or about 10° west of Mars and about two degrees north. At the end of the month Mars will have retrograded so far that the two planets will be very near together, Uranus being 4.9*m* west and

23′ south, *i. e.*, in the same field of view of an ordinary finder. They can be seen in the southeast after 7 P. M.

Neptune is in Taurus about 5° south of the Pleiades.

NEPTUNE.

	R. A. H. M.	Decl.	Rises. H. M.	Transits. H. M.	Sets. H. M.
April 5	3 45.3	+18°10′	7 28 A. M.	2 47.3 P. M.	10 06 P. M.
15	3 46.6	+18 15	6 49 "	2 08.7 "	9 28 "
25	3 48.0	+18 19	6 12 "	1 31.3 "	8 51 "

SATURN.

April 5	8 07.7	+20 49	11 37 A. M.	7 08.6 P. M.	2 40 A. M.
15	8 08.5	+20 46	10 59 "	6 30.1 "	2 01 "
25	8 10.1	+20 42	10 21 "	5 52.4 "	1 23 "

URANUS.

April 5	12 56.8	−5 20	6 15 P. M.	11 57.0 P. M.	5 39 A. M.
15	12 55.3	−5 10	5 33 "	11 16.1 "	4 59 "
25	12 53.8	−5 01	4 52 "	10 35.3 "	4 19 "

MARS.

April 5	13 31.1	−6 59	6 55 P. M.	12 31.2 P. M.	6 07 A. M.
15	13 16.5	−5 53	5 57 "	11 37.3 "	5 17 "
25	13 02.8	−4 55	5 00 "	10 44.3 "	4 28 "

JUPITER.

April 5	16 17.2	−20 20	10 38 P. M.	3 16.8 A. M.	7 55 A. M.
15	16 14.7	−20 14	9 56 "	2 34.9 "	7 14 "
25	16 11.0	−20 04	9 12 "	1 52.0 "	6 32 "

VENUS.

April 6	23 32.7	−4 29	4 46 A. M.	10 31.4 A. M.	4 17 P. M.
16	0 18.2	+0 17	4 33 "	10 37.2 "	4 42 "
26	1 03.3	+5 04	4 19 "	10 42.8 "	5 06 "

MERCURY.

April 6	23 28.6	−5 54	4 47 A. M.	10 27.0 A. M.	4 07 P. M.
16	0 21.0	−0 33	4 39 "	10 39.8 "	4 41 "
26	1 23.0	+6 34	4 33 "	11 02.4 "	5 32 "

Occultations Visible at Washington.

Date.	Star's name.	Magnitude.	IMMERSION. Wash. Mean Time. H. M.	IMMERSION. Angle f'm N. Point. °	EMERSION. Wash. Mean Time. H. M.	EMERSION. Angle f'm N. Point. °	Duration. H. M.
April 12	μ Ceti	4½	6 59	165	Star 2.5′ S. of moon's limb.		
14	63 Tauri	6	8 46	81	9 43	267	0 57
15	m Tauri	5½	5 25	87	6 48	261	1 23
16	γ^4 Orionis	5	8 41	73	9 41	293	1 01
19	δ Cancri	4	8 50	18	Star 5.7′ N. of moon's limb.		
24	80 Virginis	6	16 02	48	16 28	353	0 26
27	χ Ophiuchi	4¼	11 36	201	Star 3.6′ S. of moon's limb.		
29	B.A.C.6336	6	14 44	5	Star 2.6′ N. of moon's limb.		
May 3	45 Aquarii	6½	14 21	348	Star 6.1′ N. of moon's limb.		

Phases of the Moon.

	Central Time. D. H. M.
Last Quarter	April 3, 6 41.2 A. M.
New Moon	11, 3 7.7 "
First Quarter	19, 5 52.4 "
Full Moon	26, 12 22.2 "

Great Red Spot on Jupiter—Times when its Zero Meridian Passes the Centre of Jupiter's Disc.

Central Time.			Central Time.			Central Time.		
D.	H.	M.	D.	H.	M.	D.	H.	M.
April 2,	6	15.7 A. M.	April 12,	4	30.3 A. M.	April 22,	2	44.6 A. M.
3,	2	06.9 "	13,	12	21.4 "	22,	10	35.6 P. M.
4,	7	53.7 "	14,	6	08.3 "	24,	4	22.5 A. M.
5,	3	45.0 "	15,	1	59.5 "	25,	12	13.6 "
5,	11	36.1 P. M.	16,	7	46.3 "	26,	6	00.5 "
7,	5	23.0 A. M.	17,	3	37.5 "	27,	1	51.6 "
8,	1	14.1 "	17,	11	28.5 P. M.	27,	9	42.7 P. M.
9,	7	01.0 "	19,	5	15.4 A. M.	29,	3	29.6 A. M.
10,	2	52.3 "	20,	1	06.6 "	29,	11	20.6 P. M.
10,	10	43.4 P. M.	21,	6	53.4 "	May 1,	5	07.5 A. M.

Minima of Algol, (β Persei; R. A. 3h 01 m; Decl. +40°31′).

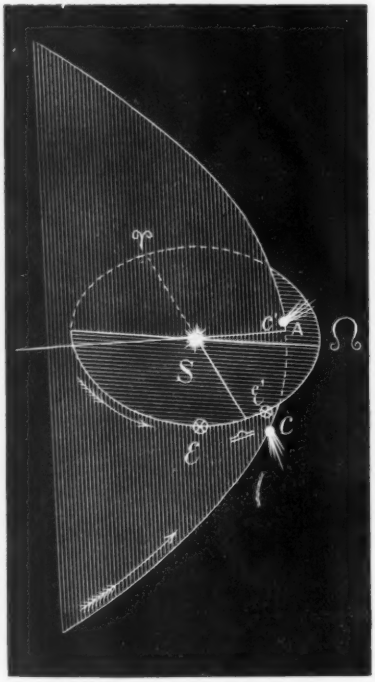
Central Time.			Central Time.			Central Time.		
D.	H.	M.	D.	H.	M.	D.	H.	M.
April 1,	10	10 A. M.	April 12,	9	26 P. M.	April 24,	8	41 A. M.
4,	6	59 "	15,	6	15 "	27,	5	30 "
7,	3	48 "	18,	3	04 "	30,	2	19 "
10,	12	37 "	21,	11	53 A. M.			

Phenomena of Jupiter's Satellites.

Central Time.				Central Time.			
D.	H.	M.		D.	H.	M.	
April 1,	11	54 P. M.	II Sh. In.	April 18,	10	22 P. M.	III Tr. In.
2,	1	56 A. M.	II Tr. In.	18,	11	48 "	III Tr. Eg.
2,	2	24 "	II Sh. Eg.	19,	10	15 "	II Tr. Eg.
2,	4	22 "	II Tr. Eg.	21,	2	51 A. M.	I Sh. In.
5,	4	36 "	I Sh. In.	21,	3	55 "	I Tr. In.
6,	1	59 "	I Ec. Dis.	22,	12	14 "	I Ec. Dis.
6,	5	06 "	I Oc. Re.	22,	3	05 "	I Oc. Re.
6,	11	05 P. M.	I Sh. In.	22,	9	20 P. M.	I Sh. In.
7,	12	02 A. M.	I Tr. In.	22,	10	01 "	I Tr. In.
7,	1	17 "	I Sh. Eg.	22,	11	33 "	I Sh. Eg.
7,	2	13 "	I Tr. Eg.	23,	12	12 A. M.	I Tr. Eg.
7,	11	33 P. M.	I Oc. Re.	23,	9	31 P. M.	I Oc. Re.
8,	1	35 A. M.	III Ec. Dis.	25,	1	51 A. M.	II Ec. Dis.
8,	3	11 "	III Ec. Re.	25,	11	08 P. M.	III Sh. In.
9,	2	29 "	II Sh. In.	26,	1	00 A. M.	III Sh. Eg.
9,	4	19 "	II Tr. In.	26,	1	46 "	III Tr. In.
9,	4	59 "	II Sh. Eg.	26,	3	11 "	III Tr. Eg.
11,	12	52 "	II Oc. Re.	26,	10	08 P. M.	II Tr. In.
13,	3	53 "	I Ec. Dis.	26,	11	26 "	II Sh. Eg.
14,	12	58 "	I Sh. In.	27,	12	33 A. M.	II Tr. Eg.
14,	1	49 "	I Tr. In.	29,	2	18 "	I Ec. Dis.
14,	3	11 "	I Sh. Eg.	29,	4	50 "	I Oc. Re.
14,	4	00 "	I Tr. Eg.	29,	11	13 P. M.	I Sh. In.
14,	10	21 P. M.	I Ec. Dis.	29,	11	46 "	I Tr. In.
15,	1	20 A. M.	I Oc. Re.	30,	1	26 A. M.	I Sh. Eg.
15,	10	27 P. M.	I Tr. Eg.	30,	1	57 "	I Tr. Eg.
16,	5	04 A. M.	II Sh. In.	30,	8	37 P. M.	I Ec. Dis.
17,	11	16 P. M.	II Ec. Dis.	30,	11	16 "	I Oc. Re.
18,	3	12 A. M.	II Oc. Re.				

"*Period of the Rotation of the Sun*, as determined by the Spectroscope" is the title of a very suggestive paper in the February number of the *American Journal of Science*, by Henry Crew of Johns Hopkins University.

Orbit of Comet a 1888. We give below a cut showing the relation of the orbits of the earth and the new comet now in view. The figure was drawn according to Finlay's elements, and by the neat method for making comet models, given by Professor William Harkness in the December number of THE MESSENGER. The letters *e* and *c* represent the positions of the earth and comet respectively at the time of discovery, Feb. 18; those of *e'* and *c'*, the positions of the same bodies April 1, approximately. By referring to Professor Harkness' article, any student or teacher of astronomy might make a model of the orbits of these bodies that would certainly prove of great interest to himself and friends, especially with this picture as a guide.



In so doing notice the position of perihelion, *A*, where the comet was March 18.18 G. M. T.; that ω is 4° 29′ north of the earth's orbit; that the Ω is 244° 6′ from the (Υ) vernal equinox; that *i* the inclination is 43° 57′ and that *q*, its perihelion distance, was 0.6846, the earth's radius being unity.

Stereoscopic Views of the Moon. Not long ago a letter, with a stereoscopic view of the moon, was received from an interested reader of THE MESSENGER in Arkansas. In the letter it was asked how stereoscopic views of the moon were made. Thinking this query and its answer may interest other readers, space is given them here.

On the card was printed "full moon," "taken by Henry Draper," and "C. Brestadt, Niagara Falls, N. Y.;" the last name being, doubtless, that of a local photographer who had mounted or copied these astronomical views obtained from the late Henry Draper of New York. The measure of the polar diameter of the discs representing the full moon was 55.5 millimeters (nearly 2¼ inches), lengthwise of the pictures. The great crater Tycho was in the diameter measured, hence the shifting of that crater in the two views, taken to give stereoscopic effect, would show approximately how the pictures were taken. From the phase in the left hand picture below, and that in the right hand picture above, it is readily seen that the displacement of Tycho in the two pictures is mainly due to libration in latitude. Projecting and roughly measuring the angle that Tycho makes with the limb in each picture, there is an apparent change of place of 6°. But astronomers know that the maximum libration of the moon in latitude can not exceed 6° 40′ 49″. The result given above is near enough to show that good conditions for stereoscopic pictures were chosen, and that the moon must have been in extreme north and south latitude, at opposite points of its orbit, in order to get 6° of libration in latitude. By noticing what is said of photography for stereoscopic views, elsewhere given, it will be seen that this was Dr. Draper's method.

A New Minor Planet (No. 273) was discovered by Palisa, March 8.548, Greenwich mean time, in R. A. 10*h* 30*m* 48*s*; Decl. + 10° 36′; daily motion—48*s* in R. A., and + 12′ in Decl.

EDITORIAL NOTES.

We have willingly set aside much miscellaneous matter to give place in this issue to a part of an excellent article on the subject of *Astronomical Photography*.

Professor Geo. W. Coakley presents the nebular hypothesis, as given by La Place, in clear and concise way, and easily within the grasp of the popular reader. Subsequently we hope to give some of the geometrical proofs used in connection with this useful paper.

The *Messenger* is indebted to Mr. Sadler, Editor of *The Journal of the Liverpool Astronomical Society*, for several late copies of that valuable publication.

The Scientific American (March 17) has the best illustrations of the site and buildings of Lick Observatory that have yet been published.

The New Comet has been seen at northern observatories. The following observation and illustration were kindly furnished by Mr. John R. Hooper of Baltimore:

"At five o'clock on the morning of the 15th of March, the comet had the appearance in the telescope as given in the drawing appended. Dawn commenced when the comet was 5° above the horizon. The nucleus was not stellar, and its magnitude equaled 6.5. I could only trace the tail 30′, expanding in straight lines as shown in cut."

On the 19th Mr. Hooper writes: "The tail of the new comet could be traced more than one degree; that the nucleus had a bright point which in clearer sky would probably have been decidedly stellar. There was also the appearance of an elongated nucleus, but this may have been due to the condition of the atmosphere which was unfavorable for observation."

Elements of Comet a, 1888, computed by Finlay of Cape Town, Africa, were received by telegraph, in cipher, from Harvard College Observatory, Feb. 29, as follows:

T = 1888, March 18.18.
ω = 4° 29′
Ω = 244 6
i = 43 57
q = .6845
Mean Eq. 1888.0

	C—O
$\Delta\lambda \cos \beta$	—.5′
$\Delta\beta$	—.2′

Dr. Wilson of Carleton College Observatory computed an ephemeris from these elements for March, by which the places of the comet until April 2 were known, and given in cut on page 168.

The following ephemeris is from the A. N., No. 2830, and was computed by Dr. B. Matthiessen:

1888.	α	δ	Log r	Log Δ	H.
	h m s	° ″			
April 1	22 7 15	+ 5 24.8			
2	10 30	6 31.1			
3	13 45	7 35.9	9.8821	0.0728	0.83
4	16 59	8 39.1			
5	20 12	9 40.7			
6	23 24	10 40.8			
7	26 36	11 39.3	9.9035	0.0934	0.68
8	29 46	12 36.3			
9	32 55	13 31.7			
10	36 2	14 25.7			
11	39 8	15 18.4	9.9267	0.1134	0.56
12	42 13	16 9.6			
13	45 17	16 59.5			
14	48 20	17 48.2			
15	51 21	18 35.7	9.9507	0.1328	0.46
16	54 21	19 21.9			
17	22 57 19	20 6.9			
18	23 0 16	20 50.7			
19	23 3 11	+21 33.5	9.9749	0.1513	0.38

Observations of Comet a 1888, made by Frank Muller with the 26-inch equatorial of the Leander McCormick Observatory:

1888. Local M. T.		No.	Comet —*	
			$\Delta\alpha$	$\Delta\delta$
h m s	°	Comp.	m s	′ ″
March 12, 17 33 35	1	1	+2 11.23	.....
13, 17 33 31	2	4	.....	+2 28.9
13, 17 40 36	2	5	+0 33.14	.....
16, 17 27 05	3	1	+4 25.14	.....
16, 17 33 07	3	1	.....	+0 30.7

1888. Local M. T.	App. α	App. δ	log pΔ	
			For α	For δ
h m s	h m s			
March 12, 17 33 35	20 59 05.87	.....	9.635 n.	.....
13, 16 33 31	.....	−20°36′15.9″	.....	0.803
13, 17 40 36	21 03 22.70	.....	9.628 n.	.....
16, 17 27 05	21 13 21.73	.....	9.618 n.	.....
16, 17 33 07	.....	−16 11 24.2	....	0.793

Mean places for 1880.0 of the comparison stars:

#	α	Red. to App.	δ	Red. to App.	Authorities.
	h m s	s	° ′ ″	″	
1	20 56 57.68	−3.04	−21 58 41.1	.....	Cinn. Zones, 3538.
2	21 2 52.52	−2.96	−20 38 43.8	−1.0 ¼	Cape 1850, 4219 + BB VI, 21.1 + Camb. 1849, 871 + Cinn. Zones 3559.
3	21 8 59.13	−2.54	−16 11 52.9	−2.0	Oe. Arg., 21244.

March 12. Nucleus 0′.1 in diameter; 4.5 magnitude; suspicion of a tail at position angle 90°. Like a blurred star. Observed in twilight. March 13. Nucleus, 0′.1; 5.5 magnitude; tail suspected as on March 12. Observed in twilight. March 16. Nucleus, 0′.2; 5.5 magnitude; tail visible for 2½′ at position angle 270°. Observed about dawn.

The estimates of magnitude were reduced by comparison with the Durchmusterung magnitudes of neighboring stars.

An astronomical friend at East Oakland Cal., speaking of the new comet says: It was picked up in the field of a comet eyepiece this morning, *March 16th*, at 5 o'clock, then being 4° above the S. E. horizon, in declination S. 16°. Shortly afterwards it was visible with a field-glass and so continued until it faded away with the approaching dawn at 5:30.

Only about 3° of the tail was visible, owing to the light. The tail is very straight, gradually diminishing in brightness as it leaves the nucleus.

Double Stars h 3823 and h 4321. These stars are contained in Flammarion's catalogue of double stars with certain or probable motion. Flammarion considers that there is great probability of orbital motion in *h* 3823 and that the position angle of *h* 4321 is certainly diminishing. Recent observations, however, indicate that there is very little, if any change in *h* 4321 and that the motion in *h* 3823 is rectilinear. The observations of the latter when platted lie approximately in a straight line, and can be satisfied by a proper motion in right ascension of ± 0s.001 and in declination of ± 0″.04. If the present rate and direction of change continues the distance will diminish until the year 1950 ± when the position angle will be 60° and the distance 6″.1.

The following are all the observations known to the writer.

h 3823 5*h* 56*m*;—31° 3′

8.3——8.4

Time.	P.A.	Dist.	Observer.
1836.90	130.5°	4.84″	J. Herschel.
76.79	119.6	3.73	H. A. Howe.
77.13	122.4	3.91	W. Upton.
81.15	123.0	2.88	H. S. Pritchett.
88.15	115.0	3.00	F. P. Leavenworth.

h 4321 10*h* 24*m*; —30° 0′

5.4——9.0

1835.20	225±	10.00	J. Herschel.
56.23	226.7	6.23	Jacob.
76.24	204.1	12.	O. Stone.
77.09	225.3	11.46	W. Upton.
77.11	226.7	10.69	H. A. Howe.
80.21	224.9	10.82	H. S. Pritchett.
88.12	225.6	11.05	F. P. Leavenworth.

Haverford College. F. P. LEAVENWORTH.

Stellar Parallax by Photography. Professor C. Pritchard, director of the University Observatory, Oxford, who, in 1886, demonstrated the practicabilty of using photography in making accurate determinations of stellar parallax, by applying his method to 61 Cygni (Mo. No. R. A. S. XLVII pp. 27, 322 and 444), has continued his investigations in that line by applying the same method to μ Cassiopeiæ and Polaris (Mo. No. XLVIII, p. 28). On each of fifty-three nights four photographic plates were taken of μ Cassiopeiæ. The resulting parallaxes from two comparison stars are:

From star (A) $\pi = 0''.0501 \pm 0''.0270$.
From star (B) $\pi = 0''.0211 \pm 0''.0235$.

"These parallaxes are extremely small, and, taking into account the large proper motion of μ Cassiopeiæ, are interesting. Bessel, in 1816, investigated the parallax of this star by means of differences of right ascensions on seventy nights, but he arrived at a *negative* value of 0.12". It is, however, both proper and interesting to remark that this research and its result apply to a time long anterior to the introduction of the heliometer in 1829. In 1356 Professor Otta Struve obtained a parallax of this star by means of micrometrical comparisons, amounting to 0.342"; a quantity well within the compass of Bessel's method in 1816."

The determination of the parallax of *Polaris* from photographs taken through the whole year is not yet completed, bnt a provisional value from selected nights is 0.052", which according to Mr. Maxwell Hall is close to the mean 0.043" of all the determinations made by preceding astronomers.

Professor Pritchard proposes hereafter to limit the observations of each star to five nights in each of four periods of the year indicated by the position of the parallactic ellipse, and hopes in this way to determine the parallax of from ten to fifteen stars in the year. He proposes first to apply this method to all the stars between the magnitudes 1½ and 2½ which attain a sufficient altitude at Oxford, and expects from experience that the parallaxes will be determinable by this method when they are not less than the thirtieth of a second of arc.

The Age of the Stars. A very interesting address delivered at the annual public session of the five academies of France,

Oct. 25, 1887, by M. Jannsen, the director of the observatory at Meudon, France, is published in the December numbers of *Ciel et Terre* and the January and February numbers of *l'Astronomie*. The principal thought is that the idea of evolution may be applied to the stars as well as to terrestrial things. The stars are not fixed and eternal but are subject to change and time. They have a beginning, a period of activity, a decline and an end. By recent advances in the study of celestial physics, especially with the spectroscope, we are enabled to know something of the actual condition and relative age of some of the stars. We may assume that the age of stars, other things being equal, will depend upon their temperature, and that their temperatures are higher in proportion as their spectra are richer in violet rays. The majority of the stars which are visible to the naked eye are white or bluish, and therefore at a high temperature; but many are yellow or orange like our sun, showing that they have passed their youth, while others are from dark orange to dark red, showing that their sidereal evolution is far advanced. In a subsequent number of THE MESSENGER we will give an extract of some length from this address.

H. C. W.

The Editor of the Journal of the Liverpool Astronomical Society, Herbert Sadler, F. R. A. S., kindly calls our attention to a letter published in the *English Mechanic*, Feb. 13, 1882, in which he gave a drawing of θ Orionis showing, as he thinks, the same small star claimed to be discovered by Mr. Alvan G. Clark in January last, by the aid of the 36-inch equatorial of Lick Observatory. Later his copy of that drawing will be given with other statements of interest furnished by Mr. Sadler.

Mr. Proctor and Professor Holden. Mr. Knobel's letter* is correct in every detail. But I am at a loss to understand why he or you (editor of THE MESSENGER) should regard it as involving a contradiction of anything in my letter. Especially, he is right in saying that I did nothing positively to advance Professor Holden's election. My letter should

* See February MESSENGER, page 89.

show that I *could* not have done anything of the kind. I repeat my statement, however, that "but for me" ("my silence," I should have said, if I had supposed it possible I could be in any degree misunderstood) Professor "Holden's name would have beeh rejected."

Though I had withdrawn my name from the Council, I had many friends in it, men of honor and probity: and I believe the Council to have been mainly constituted in 1884 of men of that stamp. Hence my certainty in regard to the fact mentioned in my letter which Mr. Knobel has not in any way contradicted. RICHARD A. PROCTOR.

The editor of THE MESSENGER thinks the *Observatory* is right in saying that "it is difficult to understand how anything less than an unreserved withdrawal of his (Proctor's former) statements will meet the case."

Catalogue of Nebulæ. Dr. Dreyer has recently completed a most important work, viz: the collection into one general catalogue of all nebulæ of which observations have been published. This catalogue, containing particulars of 7,840 objects, forms Part I of Vol. XLIX of the Mem. R. A. S., and in view of its importance to observers we believe that a certain number of additional copies have been printed by the Society, and may be purchased at 15*s* each. The work seems to have been done with a thoroughness worthy Dr. Dreyer's reputation. Besides the new collection of catalogues, the well known inaccuracy of Herschel's General Catalogue, due to the rapidity with which many of the observations were made, has necessitated a careful revision in many places; and the dozen closely printed pages of notes which are given at the end of the catalogue show that this labor has been somewhat severe.

The least satisfactory part of the catalogue must needs be the estimates of brightness, which can only be taken as approximations. The observer's eye, the weather, and the instrument used are factors in the results. It is to be hoped ere long that some photometer may be adapted to the more accurate determination of the relative brightness of nebulæ. —*Observatory*.

The comet is receding from the earth and the sun.

Continued cloudy weather has prevented observations of the new comet at Carleton College Observatory.

Focal Length and Figure of Mirrors. In an interesting article on making glass specula by hand, in *Nature* (Feb. 16, 1888), Mr. A. A. Common "considers that when the focal length exceeds 40 feet, even with a theoretically perfect mirror, the slightest touch or variation of temperature will be sufficient to destroy good definition with high powers, irrespective of the disturbing effects of the atmosphere, and he comes to the conclusion, that by decreasing the focal length, the rays cross at a less acute angle, and small variations in the reflecting surface have not so detrimental an effect—a statement that is entirely unsupported."

BOOK NOTICE.

A Manual of Descriptive Geometry with numerous Problems. By CLARENCE A. WALDO, A. M., Professor of Mathematics, Rose Polytechnic Institute, Terre Haute, Ind. Messrs. D. C. Heath & Co., Publishers: 1888; pp 77.

The purpose of this little book is to answer the question, how a solid having three dimensions can be truly represented on a surface which has but two dimensions. Readers of mathematics will at once recognize this query as the leading one in Descriptive Geometry. Such also know that it can be answered, in practice, only by a right use of the laws of projection, depending on the principles of mathematics for a scientific basis for its methods. If this be rightly done, it is true that the smallest details of projection may be represented in plane surfaces accurately in form and measurement.

After speaking of the method of solving problems in descriptive geometry, the author considers the projection of a point, line, surface and solid, giving with each a large number of exercises. The next step is the generalization of these simple concepts which calls for more knowledge of the higher mathematics. It is readily seen that this progressive course of study is calculated to show the student some of the uses and the beauties of this delightful branch by making them definite and real to the mind in the constant effort to picture them to the eye neatly and accurately.

This is a neat little book and will find friends where it is known.

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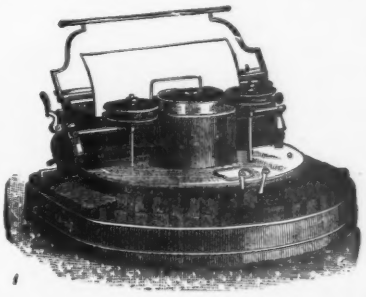

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CALENDAR FOR 1888.

Spring Term begins Wednesday, March 28th, and ends June 14th, 1888.

Term Examinations, June 12th and 13th, 1888.

Examinations to enter College, June 9th and 11th, and September 4th, 1888.

Anniversary Exercises, June 10th–14th, 1888.

Wednesday, September 5th, 1888, Fall Term begins.

JAMES W. STRONG, President,

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VICK'S FLORAL GUIDE.

A silver lining to every cloud! With the short, dull days of early winter come the cheery holidays and Vick's beautiful annual, and lo! spring already appears not far distant. We can almost see the greening grass and the blooming flowers. In the way of Catalogue, Vick's Floral Guide is unequaled in artistic appearance, and the edition of each year that appears simply perfect, is surpassed the next. New and beautiful engravings and three colored plates of flowers, vegetables and grain are features for 1888. Its lavender tinted cover, with original designs of most pleasing effects, will ensure it a prominent place in the household and library. It is in itself a treatise on horticulture, and is adapted to the wants of all who are interested in the garden or house plants. It describes the rarest flowers and the choicest vegetables. If you want to know anything about the garden, see Vick's Floral Guide, price only 10 cents, including a Certificate good for 10 cents worth of seeds. Published by James Vick, Seedsman, Rochester, N. Y.

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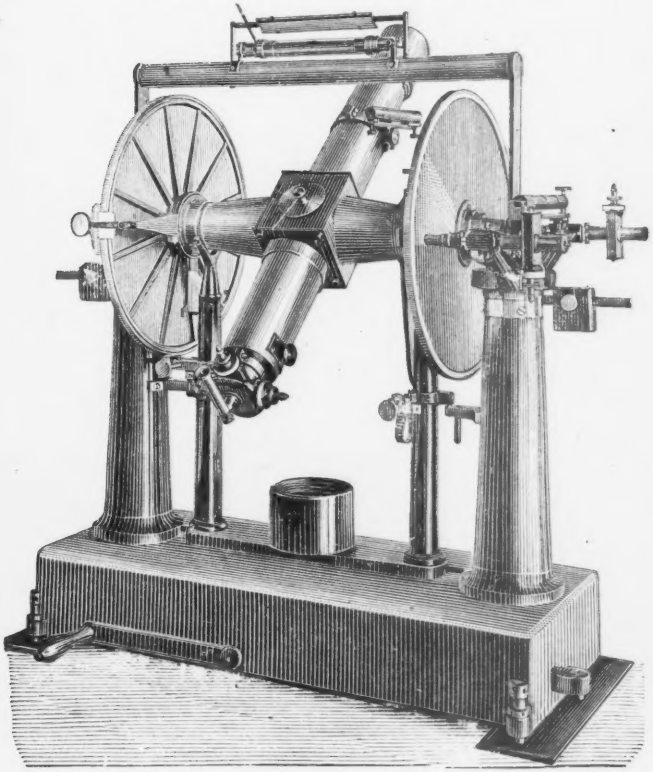

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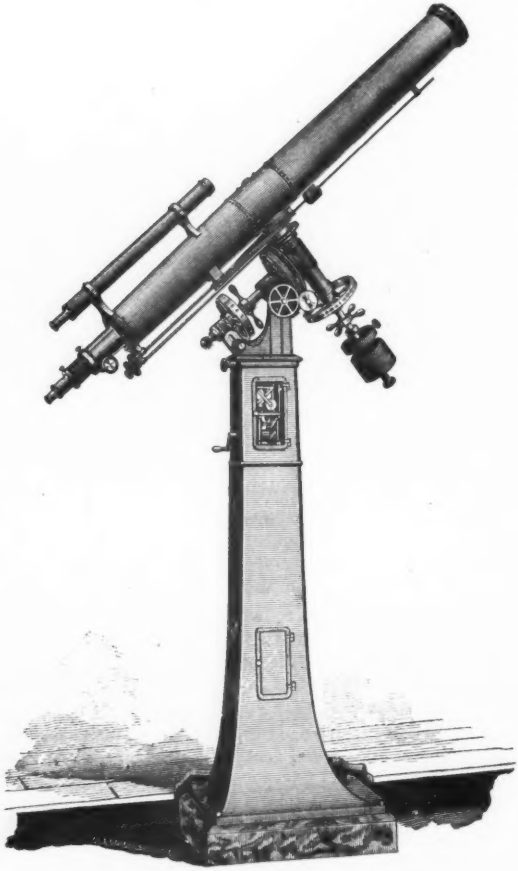

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